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Geology of Carbonatite – Alkalic Rock Complexes of Ontario

Chipman Lake Area

Districts of Thunder Bay and Cochrane

by
R.P. Sage

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Foreword

In the early 1970s, it first became apparent that the alkalic rock - carbonatite complexes of Ontario might contain significant economic mineralization. With this in mind, the Ontario Geological Survey began a program in 1974 to systematically map and evaluate these complexes.

In the Chipman Lake study, a major magnetic anomaly east of Chipman Lake, previously interpreted as a carbonatite intrusion, was found to be a magnetite-bearing syenodiorite stock, unrelated to the fenitization and carbonatite dikes in the area.

While many of these carbonatites and related rocks are not known to contain valuable mineral deposits, their systematic study will help develop criteria to direct exploration toward those complexes having the best potential.

V.G. Milne
Director
Ontario Geological Survey

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CHART (BACK POCKET)

Chart A - Figure 3.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS.

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note. Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Geology of Carbonatite – Alkalic Rock Complexes of Ontario

Chipman Lake Area

Districts of Thunder Bay and Cochrane

R. P. Sage[1]

1. Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.
Manuscript approved for publication June 1, 1983, by John Wood, Chief Geologist, Ontario Geological Survey. This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

Fenites and carbonatite dikes in the Chipman Lake area are located at 49°56′N Latitude and 85°17′W Longitude. They lie along the northern extension of the Big Bay - Ashburton Bay Fault. This fault and its subsidary fractures have controlled the emplacement of a number of Late Precambrian alkalic rock - carbonatite complexes northeast of Lake Superior.

The map-area is underlain by a predominantly Early Precambrian terrain of metavolcanics interbedded with minor metasediments and intruded by various granitic rocks. The supracrustal rocks appear to be largely well-bedded calcareous tuffs and siltstones metamorphosed to the amphibolite facies rank of regional metamorphism. Magnetite within an Early Precambrian diorite to syenodiorite instrusion has given rise to a prominent aeromagnetic anomaly east of Chipman Lake. The Big Bay - Ashburton Bay Fault passes under Chipman Lake and bisects the map-area.

The alkalic rocks of the area have relatively little economic importance. They are represented by carbonatite dikes, generally less than 1 m wide, and fenites that are associated with the dikes. The author considers that the emplacement of carbonatite dikes and development of the fenites occurred during Late Precambrian time, coeval with other alkalic events of the area.

Massive pyrite and pyrrhotite containing minor amounts of chalcopyrite outcrop along the east shore of Chipman Lake in association with amphibolite. Over the years, the occurrence has been subjected to repeated but unsuccessful testing for economic metal concentrations. The greatest economic mineral potential of the immediate area appears to lie within the metavolcanics and metasediments, which envelope the diorite to syenodiorite complex and which may contain other deposits of massive sulphide mineralization.

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Introduction

As part of a program by the Ontario Geological Survey to map alkalic rock - carbonatite complexes, an examination of the Chipman Lake area was undertaken to evaluate the importance of any alkalic or carbonatitic rocks in the area. This work showed that bedrock is dominantly Early Precambrian in age; near Chipman Lake, the Early Precambrian rocks have been diked with Late Precambrian carbonatite and have been locally fenitized. A major regional fault that passes through Chipman Lake undoubtedly controlled this intrusive and alteration activity.

Physiography

The area is one of low undulating relief. The topographic relief does not exceed 45 m. Along the east shore of Chipman Lake, cliff-faces of amphibolite rise 7.5 m to 9.0 m above the level of the lake.

The terrain is dotted with small lakes, ponds, and swamps and is crossed by several small rivers and streams. Extensive flat areas covered with sand lie southwest of Chipman Lake.

Previous Geological Work

The first recorded investigation of the area was by E.V. Neelands (1901) who reported the presence of chalcopyrite on the southwest corner of Pine Lake (now called Chipman Lake).

In 1918, P. E. Hopkins visited the same showings and reported that molybdenite and gold were also present.

No government work was subsequently done in the immediate area until the present survey. Between 1954 and 1966 several exploration companies were active in the area. N. Jones (1975) published a brief paper on the Chipman Lake area.

In 1976, W. Wright completed a B.Sc. thesis on the sulphide showings on the east side of Chipman Lake, and Biczok (1976) completed a study on the Chipman Lake pluton. In 1981, N. Jones (Professor, University of Wisconsin, personal communication, 1981) completed a study for the International Minerals and Chemical Corporation (Canada) Limited.

Field Methods

Mapping of the area was plotted on acetate overlays on 1:15 840 scale airphotos. These data were transferred to a cronoflex base at a scale of 1:15 840 supplied by the Cartographic Section of the Ontario Ministry of Natural Resources. Previous government reports and the assessment files (Assessment Files Research Office, Ontario Geological Survey) were consulted to determine the exploration history of the area.

Location and Access

The southern end of Chipman Lake is located approximately at 49°56′N Latitude and 86°17′W Longitude (Figure 1). The southern end of the lake can be reached by a logging access road heading north from Highway 11 approximately 13 km east of Long Lac. An access point to the southwest corner of Chipman Lake is located immediately east of the logging road approximately 19 km north of Highway 11. The area east, south and west of Chipman Lake has been cut over for pulp and an extensive network of logging roads and skid trails grid the area. Not all of these trails are presently accessible to vehicular traffic.

Outcrop is locally abundant east of Chipman Lake but extensive areas south and west of the lake are covered by sand.

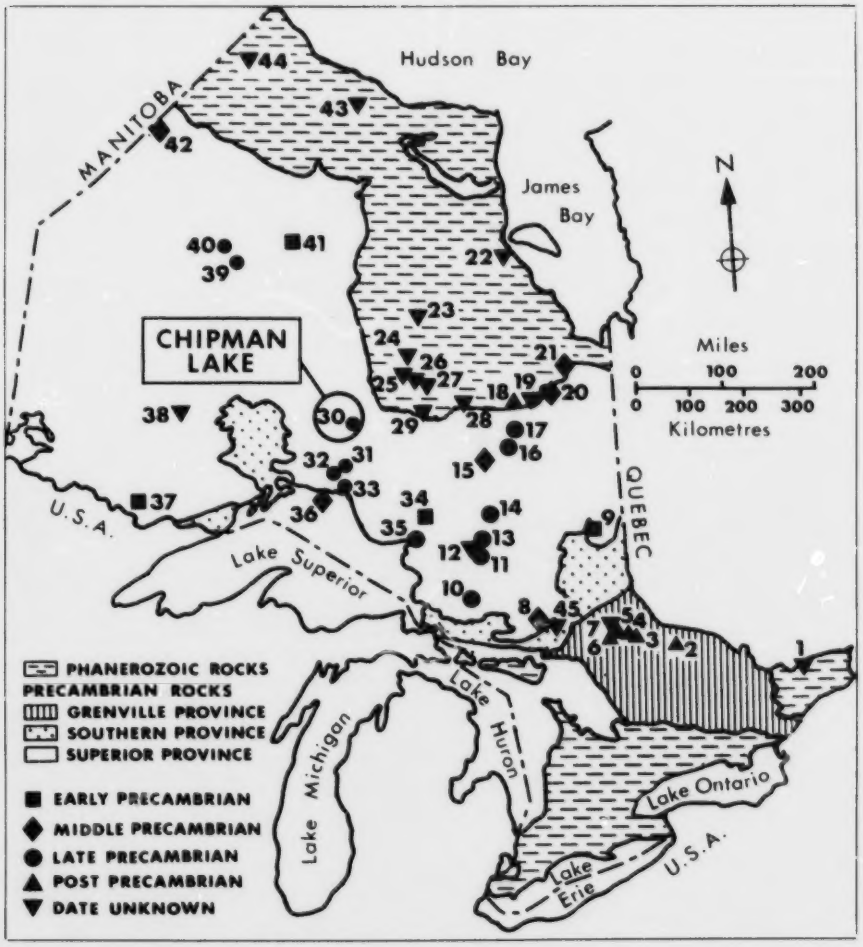

Figure 1. Key map showing location of the Chipman Lake area and carbonatite – alkalic rock complexes in Ontario.

1. Eastview
2. Brent
3. Callander B.
4. Manitou Is.
5. Burritt I.
6. Iron I.
7. Lavergne
8. Spanish R.
9. Otto Stock
10. Seabrook L.
11. Lackner L.
12. Borden Tp.
13. Nemegosenda L.
14. Shenango Tp.
15. Cargill Tp.
16. Teetzel Tp.
17. Clay-Howells
18. Hecla-Kilmer
19. Valentine Tp.
20. Goldray
21. Argor
22. Lawashi R.
23. Poplar R.
24. Albany Forks
25. L. Drowning R.
26. Kingfisher R. W.
27. Kingfisher R. E.
28. Martison L.
29. Nagagami R.
30. **Chipman L.**
31. Killala L.
32. Prairie L.
33. Port Coldwell
34. Herman L.
35. Firesand R.
36. Slate Is.
37. Poohbah L.
38. Sturgeon Narrows & Squaw L.
39. Schryburt L.
40. Big Beaver House
41. Wapikopa L.
42. "Carb" L.
43. Gooseberry Br.
44. Niskibi L.
45. Nemag L. & Lusk L.

Acknowledgments

D. Bathe, senior geological assistant, mapped the area east of Chipman Lake; Wilbur Wright, geological assistant, mapped the area southeast of Chipman Lake along the metavolcanic-granite contact. The author mapped the roads west and south of Chipman Lake and the shoreline of Chipman Lake. K. Shewbridge and Paul Chamois, geological assistants, aided in the mapping program.

Equipment was transported and some items of equipment were supplied to the party through the courtesy of J.K. Cleavely, Manager of the Geraldton office of the Ministry of Natural Resources. Ed Eckert, Supervisor for the district's junior ranger program set up a cooperative program with the Division of Mines (now Ontario Geological Survey) to provide additional assistants for the project.

General Geology

The area is underlain predominantly by Early Precambrian rocks which, in the vicinity of the south end of Chipman Lake, have been fenitized and intruded by Late Precambrian carbonatite dikes. The Early Precambrian rocks belong to the Wabigoon Subprovince of the Superior Province of the Canadian Shield.

Rocks along the south shore of Chipman Lake contain blue-green to dark green amphiboles and phlogopite in association with dolomite along joint and fracture surfaces. Discordant and concordant dikes or fracture fillings of carbonate are also common in outcrops along the south shore of the lake. The best and most spectacular outcrops of fenitized Early Precambrian rocks and carbonatite dikes occur in widely spaced exposures along the southwest flank of Chipman Lake near the access point from the logging road to the lake.

East of Chipman Lake, a strong magnetic anomaly was interpreted to be due to a carbonatite intrusion (Satterly 1968). The present mapping indicates that this anomaly (Figure 2) is caused by a magnetite-bearing, syenodiorite to diorite stock (Figure 3, Chart A, back pocket) which has been metamorphosed and locally cut by granitic dikes presumably of Early Precambrian age. This intrusion is most likely unrelated to the fenitization and carbonatite dikes found along the shore of Chipman Lake. The area of fenitization and carbonatite dike intrusion has no apparent aeromagnetic expression (see Figure 2).

The syenodiorite to diorite stock is enveloped by mafic metavolcanics which have been metamorphosed to the amphibolite facies rank of regional metamorphism. On the northeast flank of the stock the metavolcanics are well banded, and consist of boudinaged, light green, aphanitic bands and medium-grained amphibolite bands. The author believes the boudinaged light green and amphibolitic bands represent former calcareous tuff beds and non-calcareous tuff beds respectively. Individual bands are generally several centimetres thick and relatively constant in thickness across a given outcrop. One outcrop of pillowed mafic metavolcanics was observed; otherwise, primary volcanic structures are generally lacking. The metavolcanic sequence is approximately 3.2 km wide east of the syenodiorite to diorite stock and is most probably an extension of the Long Lac - Geraldton - Beardmore "greenstone" belt (Ayres et al. 1971b).

The carbonatite dikes and associated alterations are spatially associated with a major regional fault that passes through the centre of Chipman Lake. This fault is the northern extension of the Big Bay - Ashburton Bay Fault identified by Hinze et al. (1966) as a prominent feature that crosses the Lake Superior basin in a northeast direction. The northern extension of this fault onto the mainland is based on the author's interpretation of linear patterns on ERTS photography (from the Canada Centre for Remote Sensing, Ottawa). This airphoto interpretation combined with geologic data compiled by Ayres et al. (1971b) indicates that this regional fault is characterized by alkalic rock - carbonatite magmatic activity. At Chipman Lake mapping has disclosed a left lateral displacement along this fault of 0.8 km.

An incomplete K-Ar isotopic age determination on amphibole from a fenite sample collected from the west shore of Chipman Lake has indicated an age of 1022 ± 31 to 1029 ± 31 Ma for the alkalic event at Chipman Lake (J.C. Baubron, Bureau de Recherches Geologiques et Minieres, Orleans, France, personal communication, 1980). This age implies that the Chipman event is coeval with other alkalic intrusive activity in the region.

Table 1 lists the lithologies of the map-area.

EARLY PRECAMBRIAN

METAVOLCANICS

Mafic to Intermediate Metavolcanics

Amphibolitic rock units are well exposed along the east shore of Chipman Lake, and east and south of Chipman Lake. Primary volcanic textures are generally absent but

Figure 2. Aeromagnetic map of the Chipman Lake area, from ODM-GSC Map 2161G.

a sufficient number of exposures were found that display deformed primary textures such as bedding or pillows which indicate their origin. Banded amphibolite constitutes 75 to 80 percent of the mafic to intermediate metavolcanic assemblage.

Banding within the amphibolites is partly defined by variations in the relative proportions of hornblende and plagioclase. In numerous exposures east of Chipman Lake banding is, in part, due to pronounced compositional-textural variations between layers. Dark green to black, strongly boudinaged, medium-grained, hornblende-rich bands alternate with fine- to medium-grained grey to blackish grey amphibolite and fine-grained grey-green to light green bands (Photo 1). The greenish coloured bands weather high and consist of a calc-silicate mineral assemblage. The differential weathering imparts a ribbed appearance to the outcrop. One thin section, from a sample of these greenish bands collected northeast of Chipman Lake,

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE CHIPMAN LAKE AREA.

CENOZOIC
QUATERNARY
RECENT
Stream, lake and swamp deposits.
PLEISTOCENE
Glacial deposits.
Unconformity
LATE PRECAMBRIAN
CARBONATITE AND RELATED DIKE ROCKS
Carbonatite dikes; fenites; lamprophyre dikes.
Intrusive Contact
UNMETAMORPHOSED MAFIC INTRUSIVE ROCKS
Diabase dikes.
Intrusive Contact
EARLY PRECAMBRIAN
FELSIC INTRUSIVE ROCKS
UNMETAMORPHOSED GRANITIC ROCKS
Quartz monzonite to granodiorite; quartz monzonite to granite pegmatite and aplite.
METAMORPHOSED GRANITIC ROCKS
Trondhjemite to granodiorite; diorite.
Intrusive Contact
CHIPMAN LAKE STOCK
METAMORPHOSED INTERMEDIATE TO FELSIC INTRUSIVE ROCKS
Diorite; syenodiorite; hornblendite.
Intrusive Contact
METAMORPHOSED MAFIC INTRUSIVE ROCKS
Diorite to gabbro.
Intrusive Contact
METAVOLCANICS
MAFIC TO INTERMEDIATE METAVOLCANICS
Banded amphibolite; tuff, lapilli-tuff; pillow lava; medium- to coarse-grained amphibolite; minor sedimentary interbeds.

contains a visually estimated 30-40 percent quartz and 60-65 percent diopside plus epidote. The rock is fine grained, equigranular, granoblastic with straight grain boundaries. The diopside appears weakly zoned and poikilitic, containing abundant inclusions of quartz. X-ray diffraction indicated the rock to be composed of quartz, epidote and pyroxene (Geoscience Laboratories, Ontario Geological Survey). The green color is due to the epidote and pyroxene. The diffraction pattern indicates the pyroxene is diopsidic.

A thin section prepared from an adjacent amphibolite band contains an estimated 10 percent diopside, 25 percent quartz, 40 percent green to brown hornblende, and 25 percent plagioclase of calcic andesine to sodic labradorite composition. The texture is fine grained, equigranular, massive, granoblastic with straight grain boundaries. The hornblende displays a weak segregation imparting a well developed compositional layering to the rock. The diopside was concentrated along one side of the section.

Thin sections were not prepared from the hornblende-rich bands.

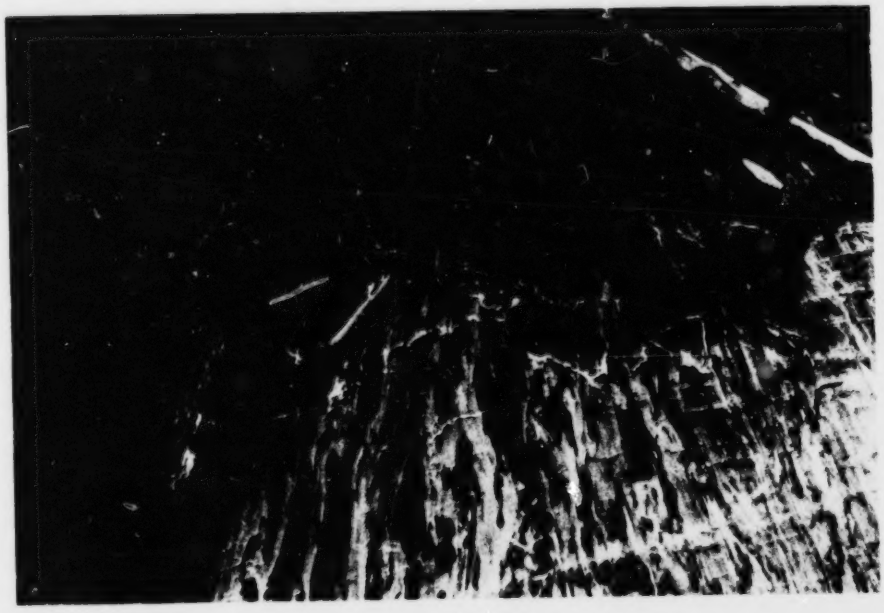

Photo 1. Dismembered hornblende-rich bands in banded amphibolite. Location P-2 on Figure 3.

The bands of greenish calc-silicate and grey-black amphibolite are not as extensively boudinaged as the hornblende-rich bands. Locally the hornblende-rich layers have the form of a horseshoe. These horseshoe-shaped, hornblende-rich bands are interpreted as limbless fold noses that resulted from deformation and dismemberment of former continuous bands (Photo 1). Rocks mapped as banded amphibolite are most abundant along the east shore of Chipman Lake and in the area northeast of the lake. Here individual bands are represented by parallel streaks that vary in width from a few millimetres to more homogeneous bands several centimetres in width.

In the northeast corner of the map-area approximately 4.8 km east of Chipman Lake the compositional banding is on the order of 3 to 7 cm in width but some bands may approach 15 cm. Within a given outcrop the banding is relatively constant in width. In the northeast corner of the area some quartz-feldspar-biotite bands are thought to be the metamorphosed equivalent of wacke. These metasedimentary interbeds reach a maximum width of 5 m and are never the dominant component in any one outcrop; where they are a major component, the outcrop was mapped as map-unit 1d. Metasedimentary units of mappable extent were not identified within the map-area.

The uniform compositional banding and presence of thin units of sedimentary origin suggest that the banded mafic to intermediate metavolcanics of the area most likely represent the metamorphosed equivalent of a sequence of well bedded, fine-grained, calcareous tuffs.

One exposure of grey-black to greenish black pillowed mafic to intermediate metavolcanics is located south of an unnamed lake approximately 3.2 km east of Chipman Lake. The pillow structures are a maximum of 25 by 5 cm in size and are

highly attenuated in the foliation plane. The structures are too highly deformed to use in determining facing directions.

In several exposures along the east shore of Chipman Lake, in exposures along the logging access road on the east side of Chipman Lake, and in the northeastern corner of the area, several relatively narrow tuff units are present. The clasts are generally highly attenuated and 2 to 4 cm in length. The length to width ratio is on the order of 10:1. One unusually large clast, 28 by 8 cm, was observed in an exposure along the logging access road east of Chipman Lake. Zones within the amphibolite containing recognizable structures that can be interpreted as former clasts generally are on the order of 1 to 2 m wide. The clasts can be distinguished on the basis of colour. They generally weather tan to buff in contrast to the dark green to black matrix. The clasts are possibly andesitic in composition. It is possible that at least some of these apparently clastic units resulted from the boudinage of more feldspathic layers within the banded amphibolites.

In the northeastern part of the map-area, 4.8 km east of Chipman Lake, a number of medium-grained, relatively massive, inequigranular, porphyritic amphibolite outcrops are present. In all probability this rock is intrusive into the other rock units of this class. Deformation and lack of critical exposure prevents a more precise determination of the relationship between this unit and associated lithologies.

On weathered surface some exposures have a knobby appearance due to former pyroxene or hornblende grains up to 4 to 5 mm diameter weathering in relief. Other exposures display glomeroporphyritic aggregates of white to buff (saussuritized) plagioclase phenocrysts. The glomeroporphyritic clots generally form no more than a visually estimated 5 percent of the rock. Variations in the abundance of this component define a banding 1 to 4 m in width in one or two outcrops. Glomeroporphyritic clots up to 2 cm in diameter were noted but the average size is likely 1 cm or less.

A group of amphibolite samples, for thin section examination, was collected in the vicinity of the south end of Chipman Lake and in the general area of most abundant carbonatite diking and fenitic alteration. The amphibolites contain approximately 50 volume percent of green to brown hornblende which sometimes contains tiny amoeboid poikilitic inclusions of plagioclase and possibly quartz. A couple of poikilitic inclusions display a myrmekitic texture but are too fine-grained for positive optical identification of the mineral phases. These inclusions are presumed to be quartz and plagioclase. The hornblende grains are irregular in outline. The anorthite content of plagioclase varies from 50 to 60 percent. The plagioclase is a mosaic of crystal aggregates. Texturally the rock is fine grained, foliated, granoblastic to granoblastic elongate, with curved to straight grain boundaries. The amphibole grains in one sample have feathery ends, suggesting actinolite; another sample contains minor amounts of chlorite and epidote.

The amphibolites represent a mafic to intermediate volcanic sequence, metamorphosed to amphibolite grade of regional metamorphism. This sequence has locally undergone a mild degree of retrograde metamorphism to the greenschist facies.

METAMORPHOSED MAFIC TO INTERMEDIATE INTRUSIVE ROCKS

Mafic to intermediate intrusive rocks are not abundant in the map-area. One exposure on the point of land projecting into Chipman Lake from the south side of Chipman Lake likely represents a small dike or sill, although it may be a thick flow centre.

This rock is fine to medium grained and composed largely of chlorite (visual identification). This small outcrop has been cut by carbonatite dikes.

In the northeast corner of the map-area one small mafic to intermediate metamorphosed dike was observed to cut banded amphibolite. This dike is no wider than 0.3 m and has been deformed along with the enclosing rocks.

CHIPMAN LAKE STOCK

Metamorphosed Intermediate to Felsic Intrusive Rocks

The possible presence of an alkalic rock - carbonatite complex in the Chipman Lake area was first suggested by Satterly (1968). This interpretation was based on the presence of a strong circular aeromagnetic anomaly that lies immediately east of Chipman Lake (Map 2161G, ODM-GSC 1963) (see Figure 2). Field relations and petrographic examination of samples indicate an Early Precambrian age for this body. Therefore, it has no relationship to the carbonatite dikes and fenitic alterations of the area which are of Late Precambrian age.

In 1976, Biczok mapped the Chipman Lake stock and subdivided it into syenite to alkali feldspar syenite and monzonite to monzodiorite to diorite. He proposed that the stock was zoned, with a syenite core and a diorite rim. Biczok (1976) did not recognize the metamorphosed nature of the Chipman Lake stock and considered the stock to be related to the carbonatite dikes and fenites.

Jones (1974, 1975) investigated the complex and subdivided the major lithologies into alkali syenite to monzodiorite. He did not recognize zoning of the complex, nor did the author. Jones (personal communication, 1981) also agreed with the author that the Chipman Lake pluton and the carbonatite dikes-fenite are unrelated. Jones and the author both consider the Chipman Lake pluton to be Early Precambrian in age and the carbonatite dikes-fenites to be Late Precambrian.

The author has classified the pluton as diorite to syenodiorite whereas both Biczok (1976) and Jones (personal communication, 1981) have classified the rocks as alkali syenite to monzodiorite. The difference in classification is based on the author's interpretation of the rock textures. The textures suggest that not all the potassic feldspar is an original rock component but is, at least in part, of metasomatic origin, possibly introduced during the younger fenitization event.

In the field, the diorite to syenodiorite weathers brown, blue-green, blackish grey, grey black, pink, pinkish grey, and grey, and on fresh surface is grey, pink, dark grey, grey-black, and brown. The rock is generally medium grained, massive, equigranular, and hypidiomorphic; it is foliated along the margins of the complex. The foliation is defined by podiform elongated feldspar phenocrysts whose milky turbid appearance indicates that they have been metamorphosed. One or two exposures at the south and southeast side of Chipman Lake have been extensively carbonatized and weather into a jagged clinkery-looking mass. Alteration along jointing within this unit in the same area imparts a well developed ramifying, ridgelike or ribbed appearance to the outcrop surfaces. These ridges may stand out as much as 25 cm in relief and may be from 1 to 3 cm in width (Photo 2). Carbonate, which accompanied the alteration and filled the joints, commonly has weathered out leaving a deep depression in the centre of the ridge or rib. Evidence for alteration of the diorite to syenodiorite is abundant on exposures along the shore of Chipman Lake. The joints commonly weather in some relief; the outcrops in places have developed a pitted surface, and broken surfaces along joint planes are coated with a dark green to black, fine-grained mixture of dolomite and phlogopite. The very fine-grained joint coatings were originally thought to be a fibrous amphibole or pyroxene (Sage 1976) but subsequent petrographic examination and X-ray diffraction studies have identified the joint coatings as a mixture of phlogopite and dolomite. The intensity of alteration generally decreases northward along the shoreline of Chipman Lake.

Mapping did not indicate any appreciable textural or compositional zoning to the intrusion other than the local presence of porphyritic textures along the periphery of the body, but more detailed mapping may alter this observation. Another form of zoning of the body does exist, as is evident by its aeromagnetic expression but this is thought to be due to variable magnetite content and not major lithologic change. Rocks within the core of the body contain sufficient quantities of magnetite to attract a hand magnet, however near the margins of the body diminishing quantities

Photo 2. Fenitized (amphibole, biotite, carbonate filled) fractures in diorite to syenodiorite. Fractures weather high giving the outcrop a pronounced ribbing. Location P-4 on Figure 3.

of magnetite are present. This feature is best illustrated by comparing the aeromagnetic map (Figure 2) with the accompanying geological map (Figure 3). The aeromagnetic high corresponds roughly to the center of the intrusion and the periphery and exposures on the west side of Chipman Lake have little or no aeromagnetic expression.

As a means of obtaining a better lithologic classification for the dioritic body, a number of samples were selected for thin section study. About half of those selected were sectioned twice and the second section was stained for potassium feldspar. In thin section the diorite to syenodiorite is visually estimated to contain approximately 60-70 percent plagioclase (An_{28-37}), 0-35 percent calcic pyroxene, 0-20 percent hornblende, 0-15 percent biotite, and 0-25 percent microcline. Minor amounts of quartz, epidote, apatite, magnetite, chlorite, actinolite, carbonate, sericite, and zircon were noted. Jones (personal communication, 1981) reported the presence of accessory sphene in samples examined by him.

The microcline forms irregular to amoeboid grains, fresh in appearance, interstitial to the plagioclase; rarely it forms amoeboid, optically continuous grains poikilitically enclosing plagioclase. Staining indicated that micro-antiperthite is present in a large number of slides. The antiperthite rims larger grains of plagioclase or occurs as discrete grains. In several slides, the micro-antiperthitic rims have myrmekitic edges. Staining also suggests that the antiperthite is represented by worm-like inclusions of potassium feldspar in plagioclase. Smaller micro-antiperthitic feldspar grains, also displaying the myrmekitic texture, are interstitial to the larger feldspar crystals and have very irregular cuspate margins that embay the larger micro-antiperthite grains. Fractures in several plagioclase grains also stained, suggesting the addition of potassium along the cracks. Patchy replacement of plagioclase by microcline was noted in one or two instances. The textural evidence strongly suggests potassium metasomatism has taken place.

The plagioclase, of oligoclase to andesine composition, forms a mosaic of interlocking grains with straight to curved grain boundaries. Some of the larger plagioclase grains display a gradation in twinning, from core to periphery, from well developed twinning to more diffused twinning to untwinned and clear. Grains that display little twinning upon staining and under high magnification are seen to be micro-antiperthite. Several thin sections contain large subrounded plagioclase grains set in a granoblastic mosaic of finer plagioclase. The larger grains distinctly resemble former porphyroclasts, set in a fine comminuted matrix, and recrystallization has apparently obliterated to a large extent the protoclastic texture. Saussuritization of the plagioclase is not common but does occur as a sprinkling of tiny highly birefringent grains in the core of the plagioclase or as an ill-defined ring of birefringent grains enclosing the core of the grain.

The hornblende is deep green in color and commonly rims pyroxene or occurs as discrete grains. It sometimes contains poikilitic euhedral apatite grains. In several instances the hornblende grains were noted to enclose small irregular, amoeboid shaped grains of quartz and/or plagioclase. In one thin section, fibrous ends have developed on the hornblende grains, suggesting the development of actinolite along the periphery of the grain.

Biotite occurs as distinct booklets of probable primary origin and as grains of probable metamorphic origin rimming hornblende and pyroxene. It has been observed as fracture fillings and as poikilitic inclusions in hornblende. Biotite plates may define a weak foliation in some of the samples. A large proportion of the biotite and hornblende appears metamorphic in origin with the general sequence being pyroxene to hornblende to biotite. This trend represents increasing addition of water to the system and lower temperature. It is unclear as to whether the metamorphism was a late-stage deuteric alteration at the time of emplacement or whether it was a later regional metamorphic event. The pyroxene is probably a primary phase. It occurs as fresh, subrounded, euhedral to irregular grains enveloped in green hornblende and more rarely biotite. A reddish brown iron stain is common along some grain boundaries.

Thin section examination indicates that the diorite to syenodiorite has undergone retrograde metamorphism and has likely undergone considerable local deformation.

The texture of the rock is fine to medium grained, equigranular to inequigranular, allotriomorphic to granoblastic, with straight, curved, and cuspate grain boundaries.

Along the border of the intrusion the diorite to syenodiorite is commonly porphyritic with elliptical to tabular feldspar phenocrysts. A syenodiorite to diorite dike with a porphyritic texture has intruded the metavolcanics near the sulphide showings on the east side of Chipman Lake indicating that the amphibolites are older than the diorite to syenodiorite intrusion. Preferred orientation of the feldspars locally imparts a well developed foliation to the rock.

Although the rock locally contains almost 25 percent potassium feldspar, it generally contains from 5 to 15 percent potassic feldspar. Some potassium has undoubtedly been added to the rock but whether all of it has been added is not clear from the textural relations. The proposed degree of potassium metasomatism will affect the ultimate classification of the rock. If all the potassium feldspar is metasomatic then the rock is a diorite; if part is metasomatic, then syenodiorite (greater than 10 percent potassium feldspar) would be the proper classification. The observed texture and alterations of the plagioclase feldspar also suggests that some sodium and silica likely accompanied the potassium metasomatic event.

The author, on the basis of texture, considers that at least some of the potassium feldspar is not an original component to the rock but has been metasomatically added. A likely time for this addition would be when carbonatite diking and fenitization occurred during the Late Precambrian. Potassium fenitization is known

to occur distally to carbonatite intrusions (Vartiainen and Woolley 1976). The lack of a clearly defined carbonatite intrusion at Chipman Lake suggests that the present level of exposure is relatively high and distal to any possible carbonatite intrusion.

A number of outcrops that were visually classified as monzonite to syenite in composition are interpreted by the author to be metasomatic rocks formed by the fenitization process.

Biczok (1976) completed chemical analyses and normative calculations on several samples from the Chipman Lake pluton. His data are given in Table 2.

The chemical data of Biczok (1976) indicate that normative plagioclase greatly exceeds orthoclase but that the rock is alkaline in nature. Table 3 gives the average major element abundances for a number of monzonitic and dioritic rocks, compiled by Nockolds (1954). The major element abundances of the Chipman samples are not comparable to the Nockolds (1954) data and the author uses the term syenodiorite to denote the alkalic nature of the samples. Nockolds did not give major element chemistry for a syenodioritic group of rocks.

Biczok (1976) reported chemical analyses and normative calculations for two amphibolite inclusions (Table 4). He interpreted the amphibolites to represent xenoliths of altered country rock.

The amphibolite samples contain more alkali metals, specifically potassium, than are usually observed in most amphibolites. While some of the inclusions within the Chipman Lake stock are undoubtedly of supracrustal origin, most of those observed by the author are relatively coarse-grained and the author would prefer to interpret them as the result of dismemberment of an earlier cumulate phase related to the stock.

On the basis of the four samples that he analyzed, Biczok (1976, p.38) suggested that alkalies and silica increase towards the rim of the complex and that total iron decreases in the same manner. Biczok (1976 p.39) suggested that the dioritic rim of the complex represents an early phase and that the syenite core is a later phase. He suggested that the stock represents at least two magma pulses and that the second pulse underwent differentiation at depth.

Jones (University of Wisconsin, personal communication, 1981) reported observing the same textures as the author in samples from the Chipman Lake pluton and classified the rocks as alkali syenite to monzodiorite (as defined by Streckeisen 1973). Using X-ray diffraction peaks, Jones determined that the feldspars from dioritic samples have orthoclase contents ranging from 18 to 24 percent which suggested to him that the feldspars are sodium-rich antiperthite and anorthoclase in composition.

Based on peak positions on X-ray diffraction patterns Jones concluded that the pyroxene in the dioritic rocks is salite and using both optical and X-ray data he concluded that the amphibole is hastingsite or ferrohastingsite.

Jones observed irregular patches of amphibole and amphibole plus biotite within the stock. He classified these as hornblendite and biotite-hornblendite. The clots are likely the amphibolite inclusions of Biczok (1976). Jones, as did the author, interpreted these clots or xenoliths as an earlier mafic phase of the Chipman Lake stock.

Jones completed chemical analyses and normative calculations on a suite of samples from the Chipman Lake stock. The data are given in Table 5.

On the basis of chemistry Jones (personal communication, 1981) considered the Chipman Lake stock to be alkaline to subalkaline, depending on the criteria used to define the alkaline nature of the rocks.

The author considers that some of the potassium was likely added to the rocks later, perhaps as part of a fenitization process. If this is true, classifying the rocks on the basis of whole rock chemistry is invalid since the addition of potassium would make the rock appear more alkalic. The author prefers to classify the stock as subalkalic.

TABLE 2. MAJOR AND TRACE ELEMENT CHEMICAL ANALYSES AND CIPW NORMS OF SELECTED SAMPLES FROM THE CHIPMAN LAKE STOCK (BICZOK 1976, P.26).

	B2-29	B4-23	B12-8A	B13-4	B13-18
Major Elements			weight percent		
SiO_2	60.2	56.3	54.1	60.1	51.7
Al_2O_3	15.8	17.5	15.6	14.9	15.7
Fe_2O_3	1.9	2.7	2.8	1.4	2.7
FeO	2.2	3.7	5.9	3.4	5.8
CaO	3.8	5.3	5.9	4.2	6.8
MgO	3.0	3.4	4.8	3.6	5.6
MnO	0.08	0.13	0.13	0.08	0.15
Na_2O	6.7	5.4	3.2	7.1	6.2
K_2O	3.45	3.90	3.38	3.56	3.46
TiO_2	0.35	0.84	0.76	0.47	0.84
P_2O_5	0.40	0.73	0.99	0.38	1.00
CO_2	1.90	0.00	0.26	0.95	0.77
H_2O	0.62	0.45	0.89	0.36	0.67
TOTAL	100.40	100.35	98.71	100.50	101.39
Trace Elements					
BaO (%)	0.09	0.12	0.14	0.12	0.20
Rb(ppm)	100	90	111	111	85
Sr(ppm)	675	1416	1287	874	1386
Y (ppm)	14.3	24.5	32	15.1	25.3
Zr(ppm)	139	171	220	142	143
Nb(ppm)	49	11.2	16.6	41	23.7
Normative Minerals					
Quartz	1.12	0.00	3.53	0.00	0.00
Orthoclase	20.30	22.96	20.23	20.93	20.16
Albite	56.44	42.05	27.42	52.33	27.67
Anorthite	2.85	11.96	18.46	0.00	4.76
Nepheline	0.00	1.87	0.00	2.27	13.02
Acmite	0.00	0.00	0.00	2.83	0.00
Orthopyrox	8.95	0.00	18.53	0.00	0.00
Clinopyrox	1.09	7.64	2.42	9.99	14.00
Olivine	0.00	5.89	0.00	6.76	10.28
Magnetite	2.74	3.90	4.11	0.60	3.86
Ilmenite	0.66	1.59	1.46	0.89	1.57
Apatite	0.94	1.72	2.38	0.90	2.34
Calcite	4.30	0.00	0.60	2.15	1.73
Water	0.62	0.45	0.90	0.36	0.66

Sample B12-8A is a diorite, others are monzonitic to monzodioritic.

TABLE 3. AVERAGE MAJOR ELEMENT CONTENTS FOR VARIOUS ROCK CLASSES (NOCKOLDS (1954).

	1	2	3	4	5	6	7
	weight percent						
SiO_2	61.86	53.39	54.58	55.36	52.97	48.55	51.86
TiO_2	0.59	1.14	0.84	1.12	1.60	1.91	1.50
Al_2O_3	16.91	14.76	16.83	16.58	18.19	16.52	16.40
Fe_2O_3	2.32	1.86	3.02	2.57	1.97	3.16	2.73
FeO	2.63	6.96	4.71	4.58	5.29	8.00	6.97
MnO	0.11	0.19	0.13	0.13	0.13	0.22	0.18
MgO	0.96	7.33	3.72	3.67	4.75	6.71	6.12
CaO	2.54	8.42	6.62	6.76	7.61	9.49	8.40
Na_2O	5.46	2.68	3.52	3.51	3.50	3.10	3.36
K_2O	5.91	3.93	4.79	4.68	1.65	0.95	1.33
H_2O	0.53	0.52	0.82	0.60	1.00	1.11	0.80
P_2O_5	0.19	0.47	0.42	0.44	0.34	0.28	0.35

1. Alkali syenite (25 analyses)
2. Augite-biotite monzonite (11 analyses)
3. Pyroxene-hornblende monzonite (9 analyses)
4. Average monzonite (46 analyses)
5. Hornblende-biotite diorite (16 analyses)
6. Hornblende diorite plus hornblende-augite diorite (10 analyses)
7. Average diorite (50 analyses)

A medium-grained, massive hornblendite occurs along the east shore of Chipman Lake and as isolated inclusions in the diorite. This rock weathers black to greenish black and is black on fresh surface. This rock-type is best exposed on the east shore of Chipman Lake. The hornblendite and the diorite are complexly intermixed, and inclusions of each rock-type are found in the other.

A thin section prepared from a sample from the east side of Chipman Lake indicates a visually estimated 60 percent hornblende, 15 percent pyroxene, 15 percent biotite, and 10 percent plagioclase. Sphene and apatite are present in trace amounts. The pyroxene occurs as cores rimmed by green hornblende. The biotite occurs as distinct booklets, and the plagioclase occurs as irregular interstitial grains.

The hornblendite is a metamorphosed pyroxenite which was probably a cumulate phase of the diorite to syenodiorite intrusion.

FELSIC INTRUSIVE ROCKS

Granitic rocks are not well exposed in most of the area examined. Large areas of granitic rock lie to the northeast and southeast of the map-area (Ayres et al. 1971a).

Metamorphosed Granitic Rocks

The oldest recognizable granitic phase is of trondhjemite to granodiorite composition. This rock has a moderate to well developed foliation which is locally a gneissosity. The foliation is due to the platey orientation of biotite in the rock. The quartz and feldspar grains are locally in elongate, podiform, polycrystalline clots. The rock is metamorphosed and contains amphibolitic inclusions. It could not be determined whether these inclusions of amphibolite were formerly part of the supracrustal assemblage that became incorporated into the granitic rock or whether they are boundinaged dike rocks that cut the granitic rock. Age relations between this unit and the amphibolite inclusions are thus unknown.

TABLE 4. MAJOR AND TRACE ELEMENT CHEMICAL ANALYSES AND CIPW NORMS FOR TWO AMPHIBOLITE SAMPLES FROM WITHIN THE CHIPMAN LAKE STOCK (BICZOK 1976, P.32-33).

	B2-12	B13-2
Major Elements	**weight percent**	
SiO_2	48.6	40.1
Al_2O_3	8.9	12.0
Fe_2O_3	5.5	5.4
FeO	8.2	9.9
CaO	10.6	12.3
MgO	9.8	10.8
MnO	0.23	0.1
Na_2O	2.2	2.5
K_2O	2.54	1.2
TiO_2	0.99	1.3
P_2O_5	1.08	2.1
CO_2	0.33	0.4
H_2O	0.80	1.0
Trace Elements		
BaO (%)	0.05	0.11
Rb (ppm)	100	67
Sr (ppm)	400	332
Y (ppm)	43	42
Zr (ppm)	154	129
Nb (ppm)	9.2	11.9
Total (%)	99.89	99.60
Normative Minerals		
Quartz	0.00	0.00
Orthoclase	15.04	7.49
Albite	18.65	7.45
Anorthite	6.93	17.81
Nepheline	0.00	7.58
Hypersthene	6.67	0.00
Diopside	29.44	21.54
Olivine	9.34	20.79
Magnetite	7.99	7.87
Apatite	5.20	5.20
Calcite	0.91	0.91
H_2O	1.08	1.08

TABLE 5. MAJOR AND TRACE ELEMENT CHEMICAL ANALYSES AND CIPW NORMS OF SELECTED SAMPLES FROM THE CHIPMAN LAKE STOCK (ANALYSES BY K. AOKI FOR JONES 1981).

	JC-11	JC-1	JC-5	JC-2	JC-4a	JC-6b
Major Elements			weight percent			
SiO_2	39.65	48.04	53.61	55.02	55.42	67.49
TiO_2	1.64	1.21	0.91	0.80	0.74	0.16
Al_2O_3	12.05	15.93	16.17	16.78	16.71	18.13
Fe_2O_3	7.70	4.56	4.04	3.03	2.91	0.59
FeO	8.71	6.09	3.80	4.23	3.84	0.74
CaO	12.77	8.32	6.10	5.45	5.57	3.91
MgO	9.85	6.11	4.63	4.18	4.60	0.73
MnO	0.23	0.17	0.13	0.12	0.09	0.02
Na_2O	2.22	4.20	4.65	4.78	5.01	6.17
K_2O	2.05	2.73	4.01	4.05	3.32	1.43
H_2O+	1.50	1.11	1.09	0.86	0.99	0.61
H_2O-	0.00	0.00	0.02	0.02	0.01	0.00
P_2O_5	1.33	0.92	0.69	0.64	0.47	0.10
Total	99.70	99.39	99.85	99.96	99.68	100.08
Trace Elements			ppm			
B	24	25	37	32	32	12
Sc	22	16	13	18	11	<5
V	320	240	160	160	155	130
Cr	20	160	90	95	160	10
Mn	2300	1550	1250	1200	1100	320
CO	80	70	42	32	42	4
Ni	105	90	65	60	82	8
Cu	565	235	80	80	110	25
Zn	195	135	120	90	97	55
Rb	42	95	132	120	72	25
Sr	440	825	725	700	710	395
Y	35	22	29	22	24	<5
Zr	130	180	220	160	65	70
Ba	460	670	810	980	980	840
La	150	180	140	120	110	13
Rb/Sr	0.095	0.115	0.182	0.171	0.101	0.063
K/Rb	405	239	252	280	383	475

TABLE 5 CONTINUED.

	JC-11	JC-1	JC-5	JC-2	JC-4a	JC-6b
Normative Minerals						
Quartz	-	-	-	-	-	16.90
Orthoclase	7.26	16.13	23.70	23.93	19.62	8.45
Albite	-	22.64	34.21	38.07	42.24	52.21
Anorthite	16.86	16.55	11.41	12.37	13.30	17.55
Leucite	3.81	-	-	-	-	-
Nepheline	10.18	6.99	2.79	1.29	0.08	-
Diopside	30.23	15.05	11.39	8.44	9.01	0.96
Olivine	12.51	9.88	6.07	7.58	7.71	-
Hypersthene	-	-	-	-	-	2.00
Magnetite	11.16	6.61	5.86	4.39	4.22	0.86
Ilmenite	3.11	2.30	1.73	1.52	1.41	0.30
Apatite	3.08	2.13	1.60	1.48	1.09	0.23
Differentiation Index	21.2	45.8	60.7	63.3	61.9	77.8

JC-11 Biotite hornblendite
JC-1 Monzodiorite
JC-5 Alkali-feldspar syenite
JC-2 Alkali-feldspar syenite
JC-4a Monzodiorite
JC-6b Porphyritic micro granite

Two thin sections from this granitic group contain a visually estimated 25 to 30 percent quartz, 5 to 15 percent biotite, 5 to 15 percent interstitial microcline, and 50 to 60 percent plagioclase (An_{30-34}). Minor accessory amounts of epidote, sphene, sericite, and apatite are also present.

Texturally the rock is fine to medium grained, equigranular, foliated to massive, granoblastic to granoblastic elongate, with straight grain boundaries.

Where hornblende is a major component of the early granitic rocks, the rock was mapped as diorite.

Unmetamorphosed Granitic Rocks

Most outcrops of granitic rock display some evidence of a later, more potassic phase of granitic intrusion. Pegmatites and aplites of quartz monzonite to granite composition are common in the granitic terrain of the area and have been observed to cut both the metavolcanics and the diorite intrusion. Coarse-grained granitic pegmatite and aplite dikes, and one quartz monzonite porphyry dike 2 m wide were observed to cut the diorite along the east shore of Chipman Lake. This late potassium-rich granitic intrusive event is believed by the author to be Early Precambrian in age.

Medium-grained, equigranular, massive, quartz monzonite units are exposed on the point of land at the south end of Chipman Lake and within the metavolcanic sequence exposed along the east shore of Chipman Lake. These homogeneous granitic units are thought to be consanguineous with similar rocks that intrude the granitic terrain marginal to the map-area and with the pegmatites and aplites found within the map-area.

On the weathered surface these rocks weather pink to buff and on fresh surface they are pink. In thin section two samples of rocks of this group contain a visually estimated 35 percent microcline, 30 to 35 percent quartz, 30 to 40 percent plagioclase (An_{32}), 1 to 7 percent biotite, 0 to 7 percent hornblende. Trace amounts of sphene, epidote, and actinolite are also present. Texturally the rock is fine to medium grained, massive, equigranular, allotriomorphic or granoblastic, with curved to lobate grain boundaries. The dikes appear to have been weakly metamorphosed.

One thin section was prepared from granitic dike rocks exposed at the rapids on the Kenogami River leading into Chipman Lake from the west. This sample has carbonate-filled fractures, and amphibole has developed along the cracks; otherwise, mineralogy and texture are similar to quartz monzonite sampled from the east and south shores of Chipman Lake.

At several places along the east shore of Chipman Lake granitic pegmatites of quartz monzonite composition cut the diorite to syenodiorite intrusion. One dike of massive quartz monzonite porphyry 2 m wide cuts the diorite on its southern flank along the shore of Chipman Lake. This dike contains a visually estimated 5 to 10 percent microcline phenocrysts up to 1.5 cm in long dimension in seriate distribution. The phenocrysts are set in a matrix of 20 percent biotite, 30 to 35 percent quartz, and roughly equal proportions of plagioclase and microcline. These granitic intrusions are thought by the author to be Early Precambrian in age and correlative to the more potassium- and silica-rich, late granitic intrusions common in Early Precambrian granitic terrains. These dikes appear unmetamorphosed and thus post-date the metamorphic-tectonic event affecting the diorite.

LATE PRECAMBRIAN

UNMETAMORPHOSED MAFIC INTRUSIVE ROCKS

Near Chipman Lake, a number of diabase dikes cut all rock types. These dikes trend roughly parallel to the long direction of Chipman Lake and consequently parallel to the regional fault that passes through the lake. Dikes 15 m and 9 m wide were noted cutting the mafic to intermediate metavolcanics on the east side of Chipman Lake. The large dike near the sulphide showings on the east side of the lake has numerous carbonatite-filled fractures, the maximum width being approximately 7 cm.

Well developed chill margins up to 15 cm wide were noted on some dikes, and in other cases a very gradational variation in grain size was noted across the dike. The texture is very fine-grained at the margins, becoming gradually medium-grained in the core.

On weathered surface the dikes are black, brownish black, grey-black, or greenish black. On fresh surface they are black.

In thin section, the massive equigranular diabase dike rocks are composed of equal amounts of plagioclase of labradorite composition, and calcic augite. Irregular to skeletal magnetite grains are a local accessory component and traces of granophyre are present in one slide. Some of the plagioclase grains are very weakly saussuritized. The texture is fine to medium grained, equigranular, massive, and subophitic.

In a bay immediately south of the metavolcanic-granite contact on the east side of Chipman Lake is a porphyritic diabase dike 4.5 m wide. This dike is similar to other diabase dikes in the area with the exception of the porphyritic texture. On weathered surface the dike displays white plagioclase phenocrysts up to 8 mm in diameter in seriate distribution grading into the groundmass. The dike has a chill margin 12 cm wide. The phenocrysts make up about 5 percent of the rock.

In thin section the rock contains glomeroporphyritic clots of saussuritized plagioclase set in a groundmass of fresh labradorite. The pyroxene is augite. The texture is fine to medium grained, equigranular, glomeroporphyritic, subophitic.

TABLE 6. MICROPROBE ANALYSES OF CARBONATE FROM CARBONATITE DIKES ALONG CHIPMAN LAKE (BICZOK 1976, P.47, SAMPLE B7-25)

Oxide	Grain 1	Grain 2	Dolomite ($Ca,Mg(CO_3)_2$)
FeO	2.55	2.04	-
MgO	19.54	19.86	21.86
CaO	28.64	27.88	30.41
Na_2O	0.01	0.00	-
MnO	0.84	0.67	-
CO_2	nd	nd	48.73

nd = not determined

CARBONATITE, RELATED DIKE ROCKS, AND FENITIZED ROCKS

Rocks along the shore of Chipman Lake are noteable for the degree of carbonate alteration. Carbonate alteration is so pervasive in local areas of the Chipman Lake Stock that weathered surfaces have a rough, jagged, clinkery appearance. Carbonate fills joints and fractures of the rocks and is invariably associated with the development of a dark green, felty coating of amphibole and phlogopite along the fracture surfaces. Petrographic examination indicates that the surfaces are coated with a very fine-grained interlocking mesh of phlogopite with subordinate amphibole. X-ray diffraction studies by the Geoscience Laboratories, Ontario Geological Survey, indicate that the carbonate is largely dolomite.

Biczok (1976, p.47) reported a microprobe analysis on the carbonate from the dikes confirming the dolomite identification. The microprobe data are given in Table 6.

Biczok (1976, p.47) considered the dolomite to be ankeritic. Biczok (1976, p.128) refered to the dolomite dikes as rauhaugite. The term rauhaugite for dolomitic carbonatite has been used by Heinrich (1966, p.12) as the equivalent of the term sovite for calcitic carbonatite; the terms alvikite (calcite) and beforsite (dolomite) have been applied to carbonatite dike rocks. In keeping with the terminology of Heinrich (1966, p.12) the dikes are classified here as beforsite.

The carbonatite occurs as dikes generally less than 1 m wide which often contain angular blocks and inclusions of host rock (Photo 3). The exposures that show the best development of fenite and carbonate diking are found along the southwest shore of Chipman Lake. Biczok (1976, p.61) reported flow texture in some of the smaller dikes. This flow texture is defined by the orientation of elongate dolomite grains parallel to the dike walls (Biczok 1976, p.61). The carbonate is generally equigranular and fine grained, but coarse-grained varieties were observed. The weathered surfaces are brown, reddish brown, and yellow brown indicating that the dolomite is ferruginous. Eight of the larger carbonate dikes were grab-sampled during routine mapping by the field party and analysed by the Geoscience Laboratories, Ontario Geological Survey, for niobium and rare earth elements. These eight samples returned from 0.01 to 0.07 percent Nb_2O_5 and only one returned detectable rare earth values; this value was 0.07 percent cerium.

The data indicate that niobium and rare earth values are too low to be of any economic interest but the presence of these elements in geochemically anomalous concentrations establishes the fact that they are related to carbonatitic activity and that they are not just low-temperature hydrothermal vein fillings. Jones (personal communication, 1981) reported that one dike contained chalcedony and he suggested that this dike is not a true carbonatite but rather a hydrothermal filling. Silicification is known to occur in a low-temperature setting distal to a carbonatite intrusive centre (Vartiainen and Woolley 1976) and thus silica deposition does not

Photo 3. Brecciated and fenitized diorite to syenodiorite, cemented with carbonatite. Location P-7 on Figure 3.

preclude a carbonatitic parentage. Heinrich (1966, p.152) considered dolomitic carbonatite to represent a lower temperature expression of carbonatite magmatism than calcite. Nesbitt and Kelly (1977, p.293) reported that inclusions found in the Magnet Cove Carbonatite indicate that carbonatite-derived fluids existed at temperatures below 70°C, well within the temperature range of a hydrothermal system.

On the basis of present data the presence of chalcedonic quartz in some carbonate-rich dikes at Chipman Lake cannot be used as a criterion to discount a carbonatitic parent.

Specimens of carbonatite commonly contain tiny euhedral crystals of pyrite up to 1 or 2 mm on an edge, fibrous amphibole, phlogopite, and rarely magnetite. The magnetite occurs in grains up to 3 cm in diameter in several pieces of float along the south shore of Chipman Lake, but visually identifiable magnetite is generally rare.

In thin section, amphibole, biotite and phlogopite, pyrite, perovskite, nepheline, and apatite were identified as accessory minerals in the carbonatite dikes.

Closely associated with the carbonatite dikes and particularly in those areas pervasively intruded by them is a blue-green to dark green amphibole.

Several of the larger dark green elongated crystals were picked from a fenite sample and tested with immersion oils to determine refractive indices. The deep green pleochroism makes such testing difficult. One index was determined as $N > 1.64, < 1.65$ and the second as $N > 1.62, < 1.63$. These values are presumably for X^1 and Z^1. The fibrous nature of the mineral prevents the determination of the third refractive index. The association of this mineral with phlogopite mica and dolomitic carbonate suggests that it likely has a high magnesium content. Based on the optical data and its associated minerals the mineral is likely the eckermanite end-member of the eckermanite-arfvedsonite series.

TABLE 7. MICROPROBE ANALYSES OF BLUE-GREEN AMPHIBOLE FROM CHIPMAN LAKE FENITES, SAMPLE BC7-25 (BICZOK 1976, P.81).

Oxide	Grain 1	Grain 2	Grain 3
SiO_2	56.32	57.17	56.71
Al_2O_3	0.14	0.13	0.22
TiO_2	0.22	0.09	0.33
FeO*	11.65	10.69	9.90
MgO	16.59	17.51	17.74
CaO	1.18	0.72	1.49
Na_2O	8.77	9.61	8.87
K_2O	1.80	1.42	2.13
MnO	0.59	0.34	0.33
CrO	0.00	0.00	0.00
H_2O	nd	nd	nd
F	nd	nd	nd

*Total iron calculated as FeO.
nd = not determined

TABLE 8. MICROPROBE ANALYSES OF PHLOGOPITE FROM CHIPMAN LAKE FENITES, SAMPLE BC7-25 (BICZOK 1976, P.87).

Oxide	Grain 1	Grain 2
SiO_2	42.77	40.95
Al_2O_3	10.75	17.28
TiO_2	0.35	0.82
FeO	6.44*	2.38
Fe_2O_3	-	0.43
MgO	23.52	22.95
CaO	0.04	0.00
Na_2O	0.35	0.16
K_2O	10.53	9.80
MnO	0.06	tr
H_2O	nd	4.71
F	nd	0.62
Total	94.81	99.87

*Total iron determined as FeO.
nd = not determined.
tr = trace.

Jones (personal communication, 1981) provisionally classified the amphibole as Na-amphibole possibly arfvedsonite. Biczok (1976, p.81) reported microprobe analyses on the blue-green amphiboles associated with the carbonatite dikes. He interpreted the amphibole to be richterite. This amphibole contains appreciable iron and magnesium and is a member of the richterite - ferro richterite solid solution series. The microprobe data are given in Table 7. The microprobe data indicate the blue-green amphibole is richterite.

Biczok (1976, p.87) reported one microprobe analysis on the phlogopite mica. The data are given in Table 8.

Thin sections indicate that the phlogopite commonly occurs along the margins of the carbonatite-filled fractures implying that it has formed by reaction of carbonatite magma with the enclosing host rock. The phlogopite forms an interlocking

mosaic of blocky grains which on the weathered outcrop surface looks like a thin, fine-grained black to dark green selvage separating the carbonatite from its host.

Thin section examination of these fenitic rocks indicates that most of the samples likely represent altered syenodiorite to diorite. Sericite, and patchy carbonate replacement of the feldspars is common. Some fresh, clear, interstitial albite and several stubby, blocky crystals of possible nepheline are present. Other minerals are characteristic of the syenodiorite to diorite rock-unit.

Powders from the eight dike rocks were submitted for assay by X-ray diffraction techniques to determine carbonate type (assays by Geoscience Laboratories, Ontario Geological Survey). They were then leached with hydrochloric acid and the residue was hand picked and examined by X-ray diffraction techniques. These studies indicated dolomite to be the dominant carbonate mineral and that calcite occurs in very minor amounts. The undissolved minerals remaining after the HCl leach were apatite, biotite, magnetite, pyrite, fluorite, amphibole, and quartz. Biczok (1976, p.46-60) reported the presence of hematite, phyrrotite, and pyrochlore in these dikes. Marcasite alteration rims on pyrite were also reported (Biczok 1976, p.56).

Biczok (1976, p.63, 69) completed analyses for major elements on three carbonatite samples and determined a number of minor element concentrations. These data are presented in Table 9.

Jones (personal communication, 1981) completed a trace element analysis of one dolomite vein sample. These data are given in Table 10.

These data, and in particular the minor element chemistry, which indicate anomalous barium, strontium and niobium, support the conclusion that the Chipman Lake carbonate dikes are carbonatites.

Biczok (1976, p.90, 91) reported major and minor element chemistry on several fenite samples from the Chipman Lake stock. These data (Table 11) indicate appreciable alumina and silica depletions, and iron, magnesium, potassium, phosphorous, and carbon dioxide addition. Anomalous niobium and yttrium values are typical of rocks associated with carbonatite complexes.

Along the east side of Chipman Lake one dike was mapped as lamprophyre. This dike cuts granitic rocks south of the granite-greenstone contact and is approximately 33 cm wide. The dike weathers black and on fresh surface is black. It weathers low and is very fine grained.

In thin section the rock was visually estimated to contain 30 percent carbonate as irregular, oblate clots which may be replacing olivine. The carbonate is turbid, clouded with iron oxide, and consists of a mosaic of tiny grains. Under high magnification tiny, unidentifiable, needle-like crystals are present in the carbonate. Turbid opaque to nearly opaque iron oxides appear to be alterations of pyroxene and/or amphibole. The remaining portion of the slide consists of clouded grains of plagioclase with patchy extinction and lacking well developed twinning. It was estimated that the anorthite content may be 30 percent. This lamprophyre dike appears to be a carbonated alkaline olivine diabase. This dike is likely related to the period of diabase dike emplacement. From the generally fresh, relatively unmetamorphosed state of the diabase dikes, the author would correlate them with the Late Precambrian.

Along the south end of Chipman Lake, one outcrop contained a small dike composed entirely of fine- to coarse-grained biotite. The dike is 65 cm wide. The age or time-stratigraphic position of this dike is unknown. No thin sections were prepared from samples of this dike.

TABLE 9. MAJOR AND MINOR ELEMENT CHEMICAL ANALYSES OF CHIPMAN LAKE CARBONATITE DIKES (BICZOK 1976, P.63, 69).

	B7-6	B7-12	B7-24
Major Elements		**weight percent**	
SiO_2	0.1	0.2	0.1
Al_2O_3	0.1	0.1	0.3
Fe_2O_3	0.2	0.6	0.5
FeO	2.4	2.4	3.2
CaO	34.4	32.4	31.4
MgO	17.7	18.4	17.6
MnO	0.57	0.62	0.10
Na_2O	0.3	0.2	0.3
K_2O	0.0	0.0	0.0
TiO_2	0.01	0.01	0.01
P_2O_5	2.08	0.36	0.22
CO_2	42.91	45.77	46.02
H_2O	0.18	0.09	0.36
Total	100.75	100.85	100.01
Trace Elements			
BaO (%)	0.02	0.03	0.02
SrO (%)	0.49	0.36	0.49
Rb (ppm)	5	5	5
Nb (ppm)	2963	434	101
Zr (ppm)	55	88	131
Y (ppm)	32	26	18

TABLE 10. TRACE ELEMENT CHEMICAL ANALYSIS OF A DOLOMITE VEIN FROM THE CHIPMAN LAKE AREA (ANALYSIS BY O. JOENSU FOR N. JONES 1981)

Trace Element	Sample JC-22
B	25
Sc	<5
V	5
Cr	5
Mn	5600
Co	30
Ni	20
Cu	20
Zn	165
Rb	3
Sr	890
Y	12
Zr	32
Ba	420
La	14
Rb/Sr	0.003

Structural Geology

The Chipman Lake stock and the Chipman Lake carbonatite dikes and associated fenites lie within the east-trending Wabigoon Subprovince of the Superior Province of the Canadian Shield (Ayres et al. 1971a). Figure 4 is a schematic diagram illustrating the major regional structure and geology of the area surrounding the Chipman Lake stock.

The most prominent structural element in the area is the fault beneath Chipman Lake. Mapping along the shore of Chipman Lake suggests that the lithologies on either side of the lake are offset approximately 0.8 km with an apparent displacement of the east side towards the north (left lateral fault). This fault is referred to by the author as the Chipman Lake Fault. The actual displacement on this fault is unknown. Using ERTS photographs (from the Canada Centre for Remote Sensing, Ottawa) the presumed southern extension of this inferred fault is suggested by the linear nature of the string of lakes that extend southward from Chipman Lake. On the basis of lineament analysis the Chipman Lake Fault joins the Boomerang Lake Fault Of Coates (1970) which passes along the east flank of the Killala Lake Alkalic

TABLE 11. MAJOR AND MINOR ELEMENT CHEMISTRY OF FENITES FROM THE CHIPMAN LAKE PLUTON (BICZOK 1976, P.90-91).

	1	2	3
Major Elements		**weight percent**	
SiO_2	53.2	57.8	69.0
Al_2O_3	7.4	14.0	15.2
Fe_2O_3	4.2	2.7	1.1
FeO	1.4	1.0	0.9
CaO	6.3	3.5	2.3
MgO	11.6	4.9	1.0
MnO	0.09	0.12	0.03
Na_2O	6.1	8.8	6.1
K_2O	5.02	4.02	2.48
TiO_2	0.04	0.20	0.22
P_2O_5	2.70	0.26	0.14
CO_2	3.04	3.66	0.59
H_2O	0.18	0.36	0.36
Total	100.95	101.32	99.42
Trace Elements			
BaO (%)	0.04	0.09	0.13
Rb (ppm)	109	104	170
Sr (ppm)	623	616	392
Y (ppm)	97	9.8	15.7
Zr (ppm)	146	123	176
Nb (ppm)	557	10.3	75

1. B7-11: Massive, coarse-grained fenite predominantly richterite and K-feldspar.
2. B7-18: Moderately fenitized granite.
3. B7-16: Relatively unfenitized granite.

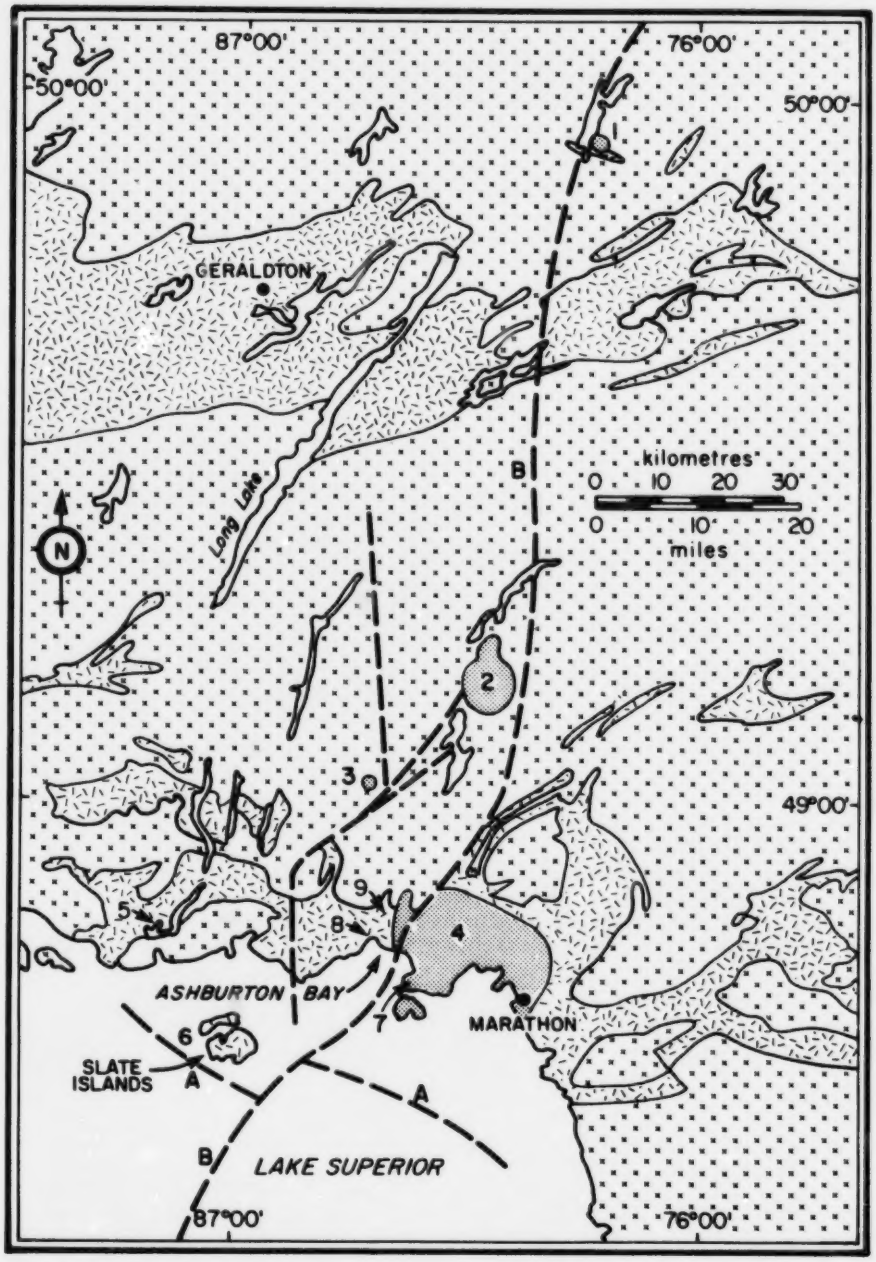

Figure 4. Sketch map showing relationship of faulting and alkalic rock magmatism north of Lake Superior.

1. Chipman L. carbonatite dikes & fenites.
2. Killala L. Alkalic Rock Complex.
3. Prairie L. Carbonatite Complex.
4. Port Coldwell Alkalic Rock Complex.
5. Gold Range Diatreme.
6. Slate Islands Diatremes.
7. Neys Diatreme.
8. Mckeller Creek Diatreme.
9. Dead Horse Creek Diatreme.

A. Michipicoten Island fault.

B. Big Bay - Ashburton Bay Fault and its extrapolated northern extension.

Rock Complex. This fault can then be traced southward, from Killala Lake to the Port Coldwell Alkalic Rock Complex on the north flank of the Lake Superior basin, where it joins with a major northeast-trending fault crossing the Lake Superior basin and identified by Hinze et al. (1966). The superposition of this fault zone on the geologic compilation map of Ontario (Ayres et al. 1971b) indicates that this fracture and its subsidiary fractures are the site for alkalic rock - carbonatite magmatism northeast of Lake Superior and define the northeastern Lake Superior alkalic rock - carbonatite petrogenetic province. Alkalic rock carbonatite complexes within this petrogenetic subprovince are the Port Coldwell and Killala Lake alkalic rock complexes and the Prairie Lake carbonatite complex. The Port Coldwell complex has been dated at 1085 ± 15 Ma, (Bell et al. 1979) and the Prairie Lake carbonatite at 1023 ± 74 Ma (Bell and Blenkinsop 1980). Bell and Blenkinsop (1980) indicated that the Killala Lake complex has an age of 1053 ± 35 Ma. Preliminary K-Ar isotopic studies of amphibole from samples collected on the west shore of Chipman Lake indicate an age of 1022 ± 31 Ma to 1029 ± 31 Ma (J.C. Baubron, Bureau de Recherches Geologiques et Minieres, Orleans, France, personal communication, 1980). The author correlates the carbonatite dikes and fenites at Chipman Lake with this Late Precambrian alkalic rock - carbonatite event that characterizes the region.

At Chipman Lake the apparent separation of similar north-dipping lithologies across the lake could infer either a vertical or horizontal movement. There is insufficient evidence to determine whether movement was vertical or horizontal, but in the opinion of the author a dominantly horizontal movement is most likely and is consistent with the model proposed by Sage (1983) for the Slate Islands which lie along this same break.

The lack of stratigraphic evidence within the metavolcanics prevents any meaningful interpretation of the structural configuration of the metavolcanics. The gneissic banding in the metavolcanics likely represents original bedding on which deformation and metamorphism has been superimposed, enhancing the compositional variation.

Along the south contact between metavolcanics and granite the granitic rocks have undergone extreme deformation and are now mylonite. The mylonite is well banded on the millimetre to centimetre scale and thin screens of amphibolite separate various mylonite zones. Porphyroclastic feldspar grains up to 7 or 8 mm in diameter are present on the weathered outcrop surface and elliptical eye-shaped pegmatitic clasts up to several centimetres in long dimension are set in the clastic recrystallized matrix. The bands within the mylonite flow around the larger clasts. The amphibolite bands within the mylonite are probably attenuated blocks derived from the adjacent supracrustals. The south margin of the supracrustal sequence is thus in fault contact with the granitic rocks.

The emplacement of the syenodiorite to diorite diapir east of Chipman Lake, which gives rise to the circular aeromagnetic anomaly on ODM-GSC aeromagnetic map 2161G, was an Early Precambrian event. The emplacement of the Chipman Lake stock deformed the supracrustal rocks which now conformably enclose the stock. Emplacement is envisaged by the author as being dominated by vertical tectonics. Mylonite along the supracrustal-granite contact may or may not be related to this period of pluton emplacement. The Chipman Lake Fault may be an old structure which was re-activated and controlled the emplacement of the stock, or it may be a much later structure. The author has studied numerous sites along the northern extension of the Big Bay - Ashburton Bay Fault and is of the opinion that the Chipman Lake Fault is likely a re-activated older structure. At Chipman Lake the age of this second period of deformation is likely Late Precambrian. On the southern extension of this zone on the Slate Islands, the author (Sage 1983) has postulated two periods of Early Precambrian deformation and one period of Late Precambrian deformation. Faulting along the Chipman Lake structure likely occurred during these same periods.

Diabase dikes in the vicinity of Chipman Lake appear to strike roughly north, parallel to the fault beneath the lake.

The localization of the fenites and carbonatite dikes in the vicinity of Chipman Lake suggests a relationship with the fault zone beneath Chipman Lake. The dikes and fenites may also in part represent the altered roof rocks covering an as yet unexposed carbonatite intrusion, or they may represent the altered wall rocks bordering a carbonatite intrusion lying beneath the waters of Chipman Lake.

An examination of the aeromagnetic pattern for the syenodiorite to diorite intrusion (see Figure 2) indicates a flattening of the anomaly along its western side beneath the waters of Chipman Lake. This flattening is likely caused by the fault beneath Chipman Lake cutting across the western margin of the magnetite-rich core of the intrusion.

Biczok (1976, p.99) attempted to relate the Chipman Lake alkalic rocks to triple junction points, failed arms, and continental rifting but did not present evidence to support the concept. Biczok (1976, p.104) rejected the suggestion of the author (Sage 1976) that faulting controlled the siting of the Chipman Lake alkalic event. He failed to recognize the regional faults along which alkalic rock - carbonatite magmatism has occurred in the region.

Petrogenesis of the Carbonatite Dikes

Biczok (1976, p.104) suggested that the carbonatite dikes and fenites at Chipman Lake are the product of fractional crystallization of an alkaline magma. This alkaline magma is considered by him to be represented by the rocks found in the Chipman Lake stock. Biczok (1976) failed to recognize field and petrographic criteria cited by the author in previous sections of this report and by Jones (personal communication, 1981) which indicate that the rocks of the Chipman Lake stock likely represent two differing ages. The two ages are separated by 1.5 billion years and therefore are unlikely to be related. Within the Port Coldwell, Killala Lake, Shenango Township, and Clay-Howells alkalic rock complexes of Ontario, carbonatite is unknown or in the case of Clay-Howells occurs as younger dikes cross cutting the syenites. Carbonatite at the Nemegosenda Lake and Lackner Lake alkalic rock complexes forms dike-like bodies and preferentially occurs with ijolitic rocks. Both the Nemegosenda Lake and Lackner Lake alkalic rock complexes consist of a nepheline syenite - ijolite suite that is unlike the Chipman Lake stock. Carbonatite is generally associated with pyroxenitic or ijolitic rocks and these rocks are not present at Chipman Lake. On the basis of field-indicated age relations and rock types known to be associated with carbonatite intrusions, it is highly unlikely that the Chipman Lake stock is related to the carbonatite dikes and fenites.

The carbonatite dikes at Chipman Lake are dolomite in composition. Heinrich (1966) has correlated intrusive age relations with carbonate mineralogy; on this basis, dolomite likely represents lower temperature carbonatite magmatism than calcite. The chemical composition of the fenites (Biczok 1976, p.90-91) indicates the addition of potassium. According to Vartiainen and Woolley (1976) and Baldock (1973), potassium fenitization occurs distally to the site of carbonatite intrusion, relative to the more common sodium fenitization. Both the carbonate composition and type of fenitization imply a distal setting to carbonatite intrusion. The author interprets the field, petrographic, and chemical data to indicate that if a discrete carbonatite intrusion exists at Chipman Lake it lies below the present level of exposure.

Biczok (1976, p.104) attributed the Chipman Lake carbonatites to fractional crystallization of an alkaline magma. Fractional crystallization is likely only one of a number of processes that have generated the Chipman Lake carbonatites.

Low degrees of partial melting in the lower crust - upper mantle (Bailey and Schairer 1966; Sun and Hanson 1975; Wass 1980), liquid immiscibility (Hamilton et al. 1979; LeBas and Handley 1979), fractional crystallization (Watkinson and Wyllie 1971) have all contributed to the generation of the carbonatite magma. As suggested by Gittins et al. (1975) fenites of the type seen at Chipman Lake are likely the result of a fenitizing solution derived from an alkali-rich aqueous carbonatite magma. The carbonatite dikes at Chipman Lake are therefore a residuum whose present composition is not equivalent to the magma from which they were derived.

The generation of the Chipman Lake carbonatites was likely far more complex than indicated by Biczok (1976).

Economic Geology

No carbonatite intrusion of appreciable size was located by members of this party. The maximum width of the carbonatite dikes observed was about 1 m and these dikes are mostly pure carbonate containing trace amounts of pyrite and blue-green to dark green acicular amphiboles.

Carbonate float is abundant along some of the shore of Chipman Lake but it contains very low concentrations of accessory minerals. Only two samples of carbonate were located that contained magnetite and in these the magnetite occurred as isolated clots, approximately 3 cm in diameter.

The relatively narrow widths of the carbonatite dikes and lack of any notable accessory mineral content suggest that the dikes have little economic potential. The similar lack of accessory minerals in the abundant carbonate float found along some portions of the beaches of Chipman Lake also indicate that if a carbonatite intrusion exists beneath the lake, it is not likely to have mineralization of potential economic interest. Magnetic surveys may be of little assistance in locating any carbonatite intrusion beneath the lake owing to the lack of magnetite in the observed carbonate.

Eight of the largest carbonatite dikes were grab sampled and assayed for niobium and rare earth elements. The results are given in Table 12.

While the niobium values substantiate the interpretation that the dikes are carbonatites the values are far too low to be of economic interest.

The presence of disseminated to massive sulphides within the amphibolitic supracrustal rocks along the east side of Chipman Lake has been known for at least 75 years (Neelands 1901). These showings were examined by members of this field party. They consist of massive to disseminated sulphides, predominantly pyrrhotite, pyrite and minor chalcopyrite. The present exposures are heavily iron-stained and mottled with the blue and green colours of azurite and malachite.

Four areas of excavation were located by members of the field party and grab sampled. Assays of the samples are given in Table 13.

The two most northerly sulphide showings, which are the most massive, and display the best copper staining, were resampled by taking chip samples at 1-foot intervals over the width of the exposure and several individual grab samples. The assays are given in Table 14.

Hopkins (1918) reported the presence of molybdenum, gold, and nickel in these sulphides in addition to copper. Assays for gold and spectrographic analyses for 30 elements (Geoscience Laboratories, Ontario Geological Survey) failed to disclose the presence of these three metals.

PROPERTY DESCRIPTIONS

CHIPMAN LAKE COPPER OCCURRENCE (MINING CORPORATION OF CANADA LIMITED) (1)

In 1954, Mining Corporation of Canada Limited conducted an exploration program over several sulphide showings located within mafic metavolcanics along the east shore of Chipman Lake. This company conducted magnetic and self potential surveys, prepared a geologic map of the area, and trenched the more promising showings. The company obtained the following copper values (information from maps in Assessment Files Research Office, Ontario Geological Survey, Toronto).

	Copper (%)	Width (feet)
North zone	0.36	2.0
	0.34	3.0
	0.34	3.0
South zone	0.29	2.0
	0.23	2.8
	0.26	2.0
	0.21	3.0

TABLE 12. NIOBIUM AND RARE EARTH ASSAYS OF CHIPMAN LAKE CARBONATITE DIKES. ASSAYS BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Sample	Niobium	Rare Earths (Cerium)
	weight percent	
CP5-2B	0.07	nd
CP5-2F	0.03	nd
CP5-4C	0.03	nd
CP6-21B2	0.02	nd
CP12-5A	0.01	0.07
CP12-19E	0.02	nd
CP4-1	0.01	nd
2P5-1C1	0.03	nd

nd = not detected.

TABLE 13. ASSAYS OF GRAB SAMPLES FROM PITS AND TRENCHES OF THE CHIPMAN LAKE COPPER OCCURRENCE. SAMPLES ARE ARRANGED FROM SOUTH TO NORTH ALONG THE SHOWINGS. ASSAYS BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Sample	Copper (%)
CP12-104B1 (south)	0.08
CP12-112A1	0.05
CP12-114B1	0.05
CP12-115A2	0.23
CP12-115B2 (north)	0.23

TABLE 14. ASSAYS OF CHIP SAMPLES (EXCLUDING DIKES) FROM THE TWO MOST NORTHERLY SHOWINGS OF THE CHIPMAN LAKE COPPER OCCURRENCE. ASSAYS BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Sample	Width (feet)	No. of Chips	Cu (%)
OC2-1	8.0	13	0.05
OC2-2	26.0	5	0.08
OC2-3	14.0	3	0.03
OC4-4	5.5	3	0.25
OC4-5	4.0	2	0.07
OC4-6	5.0	1	0.68

OC2-1: Massive sulphide mineralization from south zone.
OC2-2: Disseminated sulphide mineralization from north part of south zone.
OC2-3: Disseminated sulphide mineralization from south part of south zone.
OC4-4: Massive sulphide mineralization from north zone.
OC4-5: Disseminated sulphide mineralization from north part of north zone.
OC4-6: Disseminated sulphide mineralization from south part of north zone.

Mapping by the company suggests strike lengths of 130 feet for the north zone and 230 feet for the south zone.

CONSOLIDATED MORRISON EXPLORATIONS LIMITED [1966] (2)

In 1966, Consolidated Morrison Explorations Limited flew an airborne electromagnetic survey over the area with a 1/4 mile line spacing. Several anomalies were located but no follow-up work was initiated (Assessment Files Research Office, Ontario Geological Survey, Toronto).

INTERNATIONAL MINERALS AND CHEMICAL CORPORATION [1974] (3)

N. Jones (1974), working for the International Minerals and Chemical Corporation examined the area for its phosphate potential and prepared a report for the company (G. Erdosh, Chief Geologist, International Minerals and Chemical Corporation, personal communication, 1975). No evidence for phosphate accumulations was found and work was discontinued.

KIMBERLY-CLARK OF CANADA LIMITED [1963] (4)

From 1960 to 1963, prospectors working for Kimberly-Clark of Canada Limited prospected the area for mineralization related to the carbonatite dikes (Assessment Files Research Office, Ontario Geological Survey, Toronto; G.E. Parsons, personal communication 1975).

RECOMMENDATIONS TO THE PROSPECTOR

The presence of disseminated to massive sulphides containing uneconomic but interesting concentrations of copper indicates that the greatest economic potential of the area most likely lies within the mafic metavolcanics.

Although the carbonatite rocks in the area appear to have no economic potential, any program to locate a carbonatite intrusion should concentrate on the area covered by Chipman Lake. Such a body would likely be tabular, elongated parallel to the fault zone passing through the lake, and perhaps lying within the fault zone itself. A program to locate such a body would require detailed geophysical surveys over the ice during the winter, followed by blind drilling to identify structures and lithologic trends. If a carbonatite lies beneath the lake, it may, in all probability, be rather small in areal extent.

References

Ayres, L., Lumbers, S.B., Milne, V.G., and Robeson, D.W.
1971a: Ontario Geological Map; Ontario Department of Mines and Northern Affairs, Map 2196, Explanatory Notes.
1971b: Ontario Geological Map, West Central Sheet; Ontario Department of Mines and Northern Affairs, Map 2199, scale 1 inch to 16 miles.

Bailey, D.K. and Schairen, J.F.
1966: The System NaO-Al_2O_3- Fe_2O_3-SiO_2 at 1 Atmosphere, and the Petrogenesis of Alkaline Rocks; Journal Petrology, Vol.7, pt.1 p.114-170.

Baldock, J.W.
1973: Potassic Fenitization, Trachytes and Agglomerates at the Bukusu Carbonatite Complex, Uganda; Overseas Geology and Mineral Research, No.42, p.1-24.

Bell, K., Blenkinsop, J., and Watkinson, D.H.
1979: Rb/Sr Geochronology of Alkalic Complexes, Ontario; p.69-78 in Geoscience Research Grant Program, Summary of Research 1978-1979; Ontario Geological Survey Miscellaneous Paper 87.

Bell, K., and Blenkinsop, J.
1980: Ages and Initial ^{87}Sr-^{86}Sr Ratios from Alkalic Complexes of Ontario; p.16-23 in Geoscience Research Grant Program Summary of Research 1979-1980, Ontario Geological Survey, Miscellaneous Paper 93.

Biczok, J.
1976: The Petrography and Geochemistry of the Chipman Lake Alkaline-Carbonatite Complex; unpublished B.Sc. thesis, Lakehead University, 128p.

Coates, M.
1970: Geology of the Killala-Vein Lakes Area, Ontario Department of Mines, Geological Report 81, 35p.

Gittins, J., Allen, C.R., and Cooper, A.F.
1975: Phlogopitization of Pyroxenite: Its Bearing on the Composition of Carbonatite Magmas; Geology Magazine, Vol.112, p.503-507.

Hamilton, D.L., Freestone, I.C., Dawson, J.B., and Donaldson, C.H.
1979: Origin of Carbonatites by Liquid Immiscibility; Nature, Vol.279, p.52-54.

Heinrich, E.W.
1966: The Geology of Carbonatites; Rand McNally, Chicago, 555p.

Hinze, W.J. et al.
1966: Aeromagnetic Studies of Eastern Lake Superior; p.95-110 in The Earth Beneath the Continents, edited by J.S. Steinhart and T.J. Smith, American Geophysical Union, Monograph 10.

Hopkins, P.E.
1918: Ogahalla to Collins on National Transcontinental Railway; Ontario Bureau of Mines Annual Report for 1918, Vol.27, part 4, p.197-198.

Jones N.
1974: Report on the Chipman Lake Syenite; unpublished report prepared for the International Minerals and Chemical Corporation.
1975: A Reconnaissance Study of the Chipman Lake "Carbonatite Complex", Ontario; 21st Annual Institute on Lake Superior Geology, Northern Michigan University, Marquette, Michigan, p.8.

Le Bas, M.J., and Handley, C.D.
1979: Variation in Apatite Composition in Ijolitic and Carbonatitic Igneous Rocks; Nature, Vol.279, p.54-56.

Neelands, E.V.
1901: Exploration Survey Party No. 5: Survey and Exploration in Northern Ontario, 1900; Department of Crown Lands, Ontario, p.149.

Nesbitt, B.E., and Kelly, W.C.
1977: Magmatic and Hydrothermal Inclusions in Carbonatite of the Magnet Cove Complex, Arkansas; Contributions to Mineralogy and Petrology, Vol.63, p.271-294.

ODM-GSC
1963: Castlebar Lake; Ontario Department of Mines - Geological Survey of Canada, Aeromagnetic Map 2161G, scale 1 inch to 1 mile.

Nockolds, S.R.
1954: Average Chemical Compositions of some Igneous Rocks; Geological Society America, Bulletin, Vol.65, p.1007-1032.

Sage, R.P.
1976: Chipman Lake Area; Ontario Division of Mines, Preliminary Map P.1068, scale 1:15,840.
1978: Radioactive Diatremes North of Lake Superior; p.53-66 in Summary of Field Work, 1978, by the Ontario Geological Survey, edited by V.G. Milne et al., Ontario Geological Survey Miscellaneous Paper 82.
1983: The Geology of the Slate Islands; Ontario Geological Survey, Open File Report.

Satterly, J.
1970: Aeromagnetic Maps of Carbonatite - Alkalic Complexes in Ontario; Ontario Department Mines and Northern Affairs, Preliminary Map P.452 (revised).

Streckeisen, M.C.
1973: Plutonic Rocks: Classification and Nomenclature; Geotimes, Vol.18, p.26-30.

Sun, S.S., and Hanson, G.N.
1975: Origin of Ross Island Basanitoids and Limitations upon the Heterogeneity of Mantle Sources for Alkali Basalts and Nephelinites; Contributions to Mineralogy and Petrology, volume 52, p.77-106.

Vartiainen, H., and Woolley, H.R.
1976: The Petrology, Mineralogy, and Chemistry of the Fenites of the Sokli Carbonatite Intrusion, Finland; Geological Survey of Finland, Bulletin 280, p.87.

Wass, S.Y.
1980: Geochemistry and Origin of Xenolith-Bearing and Related Alkali Basaltic Rocks from the Southern Highlands, New South Wales, Australia; American Journal Science, Vol.280-A, p.639-666.

Watkinson, D.H., and Wyllie, P.J.
1971: Experimental Study of the Composition Join $NaAlSiO_4$-$CaCO_3$-H_2O and the Genesis of Alkalic Rock - Carbonatite Complexes; Journal of Petrology, Vol.12, p.357-378.

Wright, W.
1976: Sulfide Showings of Chipman Lake, O'Meara Township, Northern Ontario; unpublished B.Sc. Thesis, University of Western Ontario, 17p.

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86°18'

86°10'

49°59'

CHIPMAN

LAKE

CHIPMAN LAKE FAULT

under construction

Parrée Lake

4b 5a

4b,i,a

4b,h,i
1a,5b,6b

4h,b,
1a

4b,l

4h,3c,F
4i,b,
3c,F

6c,a,F

3a,4i,
6a,F

3a,
6a,F

1a,5a

1a,4h,i,2a,
6a,F

3a,6a

3a,b

3b,
6a

3a,4i,
6a

4b,h,i
1b

1a

4h

1a,3c

3a, pe, py, cp
F

1a,4h

P-7

P-5

B13-4

B13-20

B12-8a

JC-11

1

31°
17°
88°
45°
60°
60°
63°
63°
76°
70°
67°
67°
38°
40°
55°
37°
64°
62°
53°
66°
55°

CHIPMAN LAKE AREA
LEGEND

CENOZOIC

QUATERNARY

RECENT

Stream, lake, and swamp deposits

PLEISTOCENE

Glacial deposits[a]

Unconformity

LATE PRECAMBRIAN

CARBONATITE AND RELATED DIKE ROCKS

6a Carbonatite dike, fine- to coarse-grained, trace amounts of pyrite and pyrrhotite

6b Lamprophyre, dark brown to black, fine carbonate-rich dike rock

6c Biotite dike

FENITES

F — Fenitized rocks

Intrusive Contact

UNMETAMORPHOSED MAFIC INTRUSIVE RO

5a Diabase, massive, fine-grained

5b Diabase, massive, fine-grained, porph

Intrusive Contact

EARLY PRECAMBRIAN

FELSIC INTRUSIVE ROCKS

UNMETAMORPHOSED GRANITIC ROCKS

4h Quartz monzonite to granodiorite, mass grained, equigranular, with local coarse pegmatite segregations

4i Quartz monzonite to granite pegmatite

METAMORPHOSED GRANITIC ROCKS[b]

4a Diorite, massive to foliated, medium-gra equigranular

4b Trondhjemite to granodiorite, massive locally cataclastic with well-developed gn near metavolcanic-granitic contacts

Intrusive Contact

CHIPMAN LAKE STOCK

METAMORPHOSED INTERMEDIATE TO FEL ROCKS[b]

3a Diorite, syenodiorite, massive, medium- granular, locally foliated

3b Hornblendite, medium- to coarse-grain equigranular rock composed of 90% hornblende

3c Syenitic-appearing rocks[c]

Intrusive Contact

METAMORPHOSED MAFIC INTRUSIVE ROC

2a Diorite to gabbro, fine- to medium-gra

Intrusive Contact

METAVOLCANICS

Chart A
Chipman Lake Area
Figure 3

CHIPMAN LAKE AREA
LEGEND

CENOZOIC

QUATERNARY
RECENT
Stream, lake, and swamp deposits
PLEISTOCENE
Glacial deposits[a]

Unconformity

LATE PRECAMBRIAN

CARBONATITE AND RELATED DIKE ROCKS
6a Carbonatite dike, fine- to coarse-grained, locally contains trace amounts of pyrite and pyrrhotite
6b Lamprophyre, dark brown to black, fine-grained, carbonate-rich dike rock
6c Biotite dike

FENITES
F — Fenitized rocks

Intrusive Contact

UNMETAMORPHOSED MAFIC INTRUSIVE ROCKS
5a Diabase, massive, fine-grained
5b Diabase, massive, fine-grained, porphyritic

Intrusive Contact

EARLY PRECAMBRIAN

FELSIC INTRUSIVE ROCKS
UNMETAMORPHOSED GRANITIC ROCKS
4h Quartz monzonite to granodiorite, massive medium-grained, equigranular, with local coarse-grained pegmatite segregations
4i Quartz monzonite to granite pegmatite and/or aplite

METAMORPHOSED GRANITIC ROCKS[b]
4a Diorite, massive to foliated, medium-grained, equigranular
4b Trondhjemite to granodiorite, massive to schistose, locally cataclastic with well-developed gneissic structure near metavolcanic-granitic contacts

Intrusive Contact

CHIPMAN LAKE STOCK

METAMORPHOSED INTERMEDIATE TO FELSIC INTRUSIVE ROCKS[b]
3a Diorite, syenodiorite, massive, medium-grained, equigranular, locally foliated
3b Hornblendite, medium- to coarse-grained, massive, equigranular rock composed of 90% or more hornblende
3c Syenitic-appearing rocks[c]

Intrusive Contact

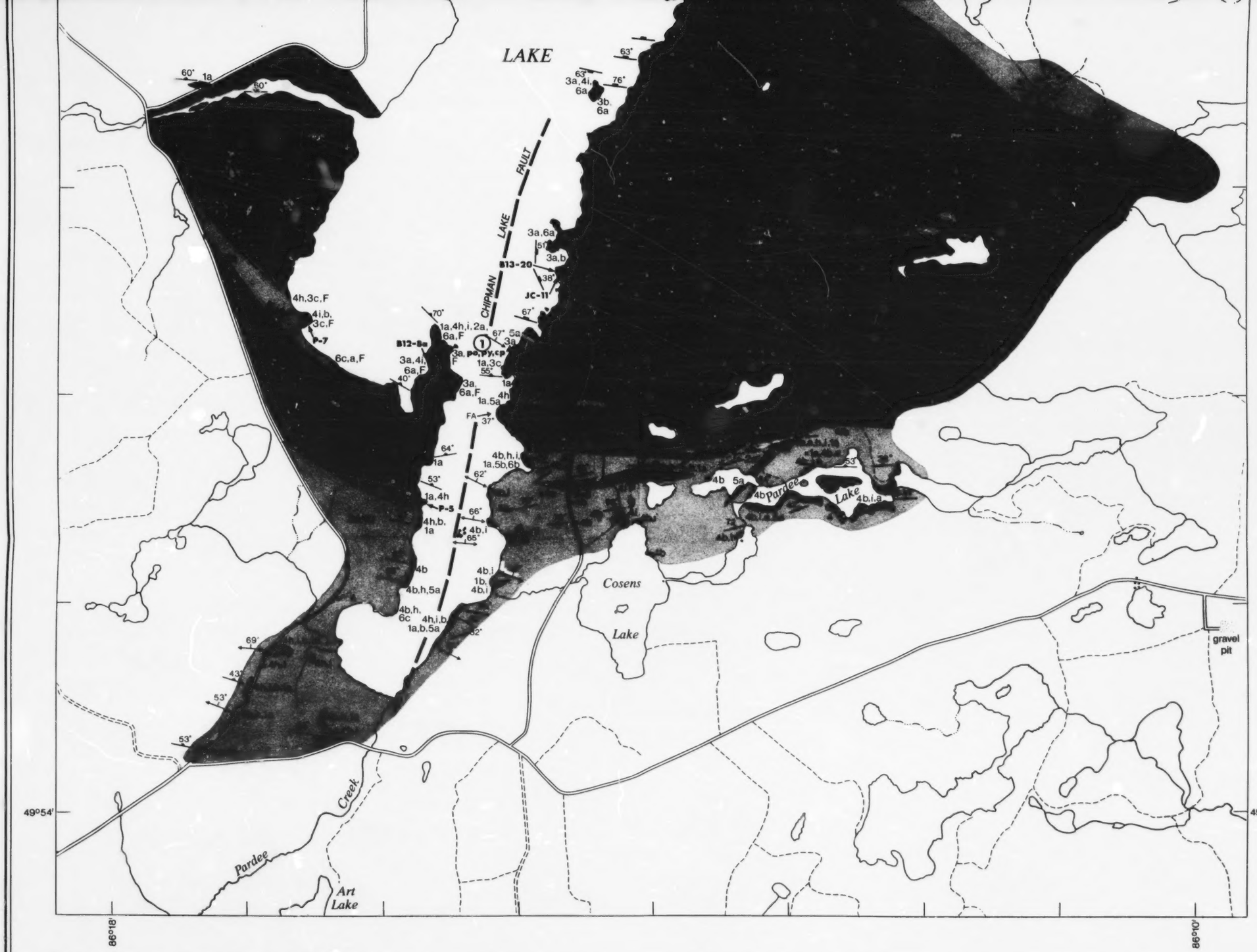
METAMORPHOSED MAFIC INTRUSIVE ROCKS
2a Diorite to gabbro, fine- to medium-grained, massive[d]

Intrusive Contact

METAVOLCANICS
MAFIC TO INTERMEDIATE METAVOLCANICS
1a Banded amphibolite

SYMBOLS

- Glacial striae
- Small bedrock outcrop
- Area of bedrock outcrop
- 75° — Banding gneissosity; inclined, vertical
- 70° — Jointing
- 90° — Schistosity; inclined, vertical
- 20° — Lineation with plunge; (FA Fold axis, H Hornblende)
- Fault, inferred
- Geological contact; known, inferred
- Airborne electromagnetic conductor; data compiled from file 63.2081 (Assessment Files Research Office, Ontario Geological Survey, Toronto)
- ▲ Mineral occurrence
- ① Property
- P-2 — Photograph location (see report)
- BCL-7-12 — Sample collected by Biczok (1976)
- JC-4 — Sample collected by Jones (1981)
- Logging access road (all-weather)
- Logging road
- Skid trail



Intrusive Contact

UNMETAMORPHOSED MAFIC INTRUSIVE ROCKS

5a Diabase, massive, fine-grained

5b Diabase, massive, fine-grained, porphyritic

Intrusive Contact

EARLY PRECAMBRIAN

FELSIC INTRUSIVE ROCKS

UNMETAMORPHOSED GRANITIC ROCKS

4h Quartz monzonite to granodiorite, massive m grained, equigranular, with local coarse-grain pegmatite segregations

4i Quartz monzonite to granite pegmatite and/c

METAMORPHOSED GRANITIC ROCKS[b]

4a Diorite, massive to foliated, medium-grained, equigranular

4b Trondhjemite to granodiorite, massive to sch locally cataclastic with well-developed gneissic near metavolcanic-granitic contacts

Intrusive Contact

CHIPMAN LAKE STOCK

METAMORPHOSED INTERMEDIATE TO FELSIC I ROCKS[b]

3a Diorite, syenodiorite, massive, medium-grain granular, locally foliated

3b Hornblendite, medium- to coarse-grained, m equigranular rock composed of 90% or more hornblende

3c Syenitic-appearing rocks[c]

Intrusive Contact

METAMORPHOSED MAFIC INTRUSIVE ROCKS

2a Diorite to gabbro, fine- to medium-grained, m

Intrusive Contact

METAVOLCANICS

MAFIC TO INTERMEDIATE METAVOLCANICS

1a Banded amphibolite

1b Tuff and lapilli-tuff, occasionally clasts are mo (andesitic) than matrix

1c Pillow lava

1d Banded amphibolite with minor metasedime interbeds

1e Medium- to coarse-grained locally porphyriti amphibolite[e]

NOTES

a. Glacial deposits are represented by the lighter colour of the map.

b. Age relationships between metamorphosed granitic rock Chipman Lake Stock are uncertain.

c. Resulting from extreme alteration of diorite to syenodiorite granitic dike rocks.

d. These are possibly thick flow centres or sill-like intrusions volcanic sequence.

e. Most likely intrusive into Units 1a to 1d.

ABBREVIATIONS

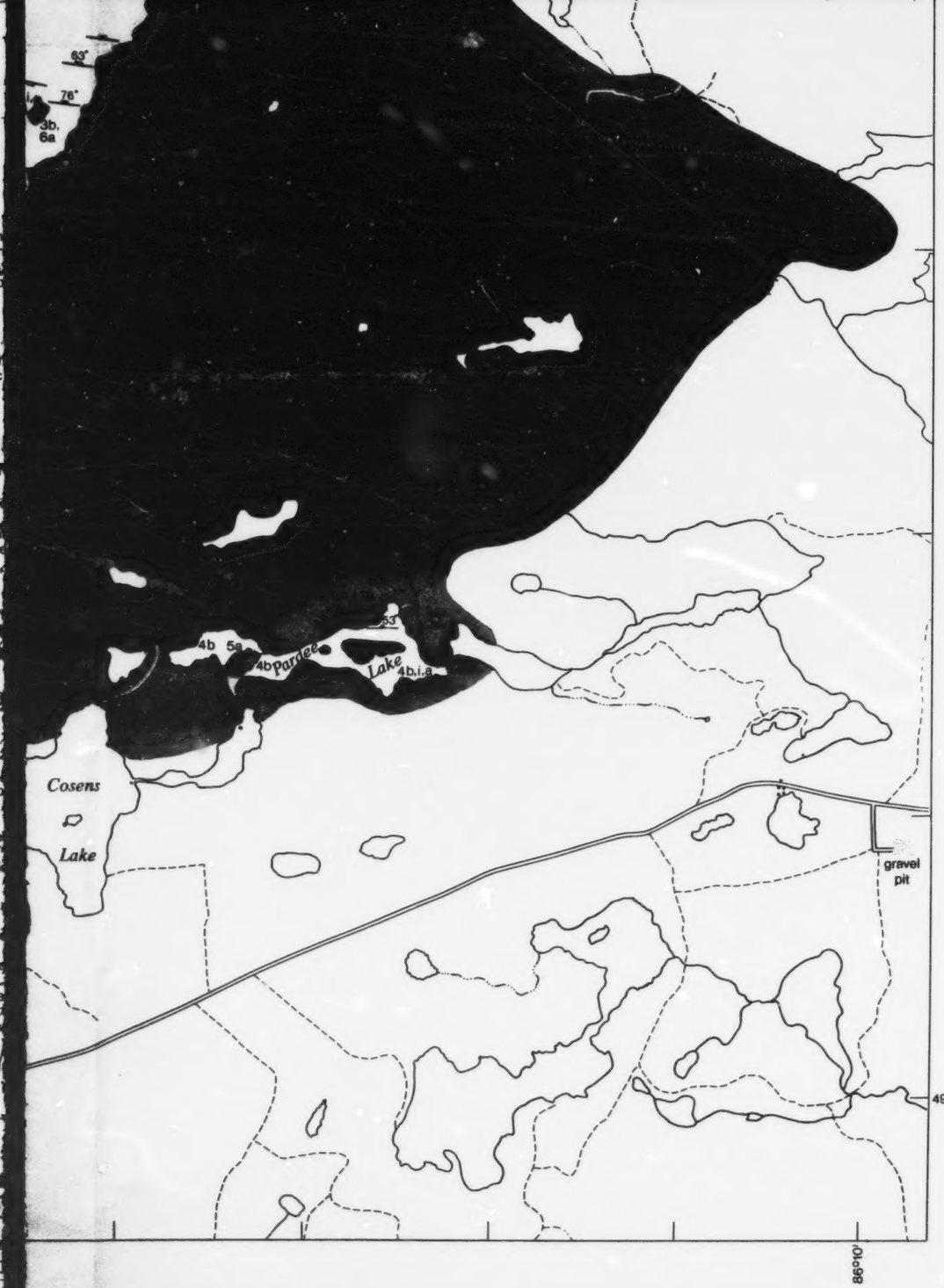
cp Chalcopyrite
po Pyrrhotite
py Pyrite

Scale

Metres 1000 0

Chains 80 60 40 20 0

Figure 3. Geology of the Chipman Lake area, Districts of Thunder Bay and Cochrane. Scale 1:31,680. Geology by R.P. Sage and assistants, 1975.



Intrusive Contact

UNMETAMORPHOSED MAFIC INTRUSIVE ROCKS

- 5a Diabase, massive, fine-grained
- 5b Diabase, massive, fine-grained, porphyritic

Intrusive Contact

EARLY PRECAMBRIAN

FELSIC INTRUSIVE ROCKS

UNMETAMORPHOSED GRANITIC ROCKS

- 4h Quartz monzonite to granodiorite, massive medium-grained, equigranular, with local coarse-grained pegmatite segregations
- 4i Quartz monzonite to granite pegmatite and/or aplite

METAMORPHOSED GRANITIC ROCKS[b]

- 4a Diorite, massive to foliated, medium-grained, equigranular
- 4b Trondhjemite to granodiorite, massive to schistose, locally cataclastic with well-developed gneissic structure near metavolcanic-granitic contacts

Intrusive Contact

CHIPMAN LAKE STOCK

METAMORPHOSED INTERMEDIATE TO FELSIC INTRUSIVE ROCKS[b]

- 3a Diorite, syenodiorite, massive, medium-grained, equigranular, locally foliated
- 3b Hornblendite, medium- to coarse-grained, massive, equigranular rock composed of 90% or more hornblende
- 3c Syenitic-appearing rocks[c]

Intrusive Contact

METAMORPHOSED MAFIC INTRUSIVE ROCKS

- 2a Diorite to gabbro, fine- to medium-grained, massive[d]

Intrusive Contact

METAVOLCANICS

MAFIC TO INTERMEDIATE METAVOLCANICS

- 1a Banded amphibolite
- 1b Tuff and lapilli-tuff, occasionally clasts are more felsic (andesitic) than matrix
- 1c Pillow lava
- 1d Banded amphibolite with minor metasedimentary interbeds
- 1e Medium- to coarse-grained locally porphyritic amphibolite[e]

NOTES

a. Glacial deposits are represented by the lighter coloured parts of the map.
b. Age relationships between metamorphosed granitic rocks and the Chipman Lake Stock are uncertain.
c. Resulting from extreme alteration of diorite to syenodiorite and later granitic dike rocks.
d. These are possibly thick flow centres or sill-like intrusions into the volcanic sequence.
e. Most likely intrusive into Units 1a to 1d.

ABBREVIATIONS

cp	Chalcopyrite
po	Pyrrhotite
py	Pyrite

- Banding gneissosity; inclined, vertical
- Jointing
- Schistosity; inclined, vertical
- Lineation with plunge; (FA Fold axis, H Hornblende)
- Fault, inferred
- Geological contact; known, inferred
- Airborne electromagnetic conductor; data compiled from file 63.2081 (Assessment Files Research Office, Ontario Geological Survey, Toronto)
- ▲ Mineral occurrence
- ① Property
- **P-2** Photograph location (see report)
- **BCL-7-12** Sample collected by Biczok (1976)
- **JC-4** Sample collected by Jones (1981)
- Logging access road (all-weather)
- Logging road
- Skid trail

PROPERTIES

1. Chipman Lake Copper Occurrence (Mining Corporation of Canada Limited)
2. Consolidated Morrison Explorations Limited [1966]
3. International Minerals and Chemical Corporation [1974]†
4. Kimberly-Clark of Canada Limited [1963]†

*A date in square brackets indicates the last year of exploration activity on land now open for staking.
†Not shown on map.

Scale 1:31,680 or 1 Inch to ½ Mile

Metres 1000 0 1 2 3 Kilometres

Chains 80 60 40 20 0 1 2 Miles